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DEOXIDATION OF STEEL

Cleanliness is one of the important requirements of steels; their quality is to some extent dependent upon this factor, and the results achieved depend largely upon the amount and character of the deoxidiser used, the condition of the metal when the additions are made, and of the slag, if the additions are made in the bath, and the time during which they are allowed to function. Many deoxidising agents may be used; in this article the value of silicon-manganese alloys for the purpose are discussed.

THE importance of cleanliness in the manufacture of steel is now recognised by makers and users. It has become essential because of rigid specifications covering a wide range of compositions, the tendency being to concentrate on quality rather than quantity. With a view to improving knowledge on what factors contribute to this desirable quality, considerable study has been devoted to the types and distribution of inclusions occurring in steel made by various methods. It is generally admitted that freedom from injurious inclusions is particularly desirous in steels which are likely to be subjected to severe transverse stresses, but specifications are becoming so rigid that every effort must be made to manufacture a clean steel, since it is appreciated that, other things being equal, a clean steel is better than a dirty one, even though uncertainty prevails regarding the effects of various types of inclusions.

One of the most important factors affecting the cleanliness and quality of a steel is deoxidation. The results achieved are largely dependent upon the amount and character of the deoxidiser used, the condition of the metal at the time of making the additions, and of the slag, if the additions are made in the bath, and the time during which they are allowed to function. In a perfectly deoxidised steel all iron oxide, and whatever carbon monoxide may have been present, would be completely removed, and there would be no products of deoxidation. Whether this will ever be achieved in practice is doubtful, but it is the ideal to which manufacturers are endeavouring to approach as closely as possible. Actually, in making steels which require high-tensile, impact, and fatigue strengths, the steel-maker must compromise between the two limits—that is, no iron oxide (and carbon monoxide) left in the steel, also no products of deoxidation. The amount of oxides removed is proportional to the amount and strength of the deoxidiser or deoxidisers used and the percentage elimination of the products of deoxidation is governed by a number of factors.

Many deoxidising agents are used to remove these oxides; these include aluminium, silicon, manganese, calcium, titanium, or combinations of these. They are used in sufficient quantities to kill the steel completely, and produce a steel as free as possible from non-metallic inclusions. These elements have a great affinity for oxygen, and combine with it to form oxides or silicates which rise more readily to the surface, but not all the products of deoxidation can be removed in practice, and for this reason care must be exercised in the selection and application of a deoxidiser in order to achieve the most desirable result with reasonable regularity. During recent years considerable study has been given to the subject by investigators in most steel manufacturing countries. Of these, the contributions of Herty and Fitterer[1] are not the least noteworthy, covering as they do a systematic study over a period of years, much of whose investigations with manganese and silicon are considered in this article.

Casting an ingot from two ladles.

Killed steels have never been successfully applied for deep drawing processes because with normal deoxidation practice, low-carbon killed steel is almost invariably extremely dirty. To obtain the desired qualities for deep drawing, the steel is rimmed—that is to say, deoxidised with manganese and perhaps a small amount of aluminium—the resultant product being of high purity in the skin of the ingot, but badly segregated at the centre of the ingot, particularly in the upper-central section. This segregation necessitates a very heavy top discard, and one of the major segregates is carbon, which renders the steel too hard to draw properly. If clean, low-carbon killed steel could be made successfully, much better ingot yields would be obtained than by the present rimming practice. Furthermore, banded structures and outside and inside seams, which are stated to be due in a large measure to blowholes in the ingot, are defects which are very difficult to control in rimmed steel. These defects would be reduced in a clean killed steel.

[1] U.S. Bureau of Mines, R.I. 3081.

Present Use of Deoxidisers.

In the manufacture of dead-killed steel, it is customary to use silicon and manganese, and at times aluminium or other strong deoxidisers, such as zirconium, calcium, titanium, or combinations of these, to kill the steel completely and to produce a steel as free as possible from non-metallic inclusions. The usual practice in the manufacture of the forging grades of steel has been to add silicon and manganese in the furnace in various ways, and to complete the deoxidation with silicon in the ladle. The silicon addition in the furnace is made to prevent the carbon dropping while the best analysis is being checked, and the manganese to raise the manganese content of the finished steel to the specified percentage. Sometimes other strong deoxidisers, such as mentioned above, are added to the steel in the ladle to complete deoxidation. In most dead steels, however, some non-metallic inclusions are left in the steels because : (*a*) Sufficient time has not been allowed for the particles to be eliminated ; (*b*) it is highly probable that some of the particles are of such a nature that no matter how long the steel is allowed to stand they cannot be eliminated ; and (*c*) some of the particles may be formed at the time of solidification of the steel by the precipitation of inclusion-forming material which is soluble in molten steel.

A careful study of the reactions involved and microscopic examination of the type and number of inclusions found in steels deoxidised with various alloys led to the conclusion that the number of inclusions could be greatly decreased and their form and distribution so changed as to be less detrimental to the physical properties of the steel by a proper choice of the alloys used for deoxidation.

Rate of Elimination of Inclusions.

The factors which affect the rate of elimination of non-metallic inclusions from steel are : (*a*) The size of the particles ; (*b*) the difference in density between the particles and the steel bath ; and (*c*) the viscosity of the steel.

The maximum rate of rise of a liquid particle in a liquid medium may be calculated from the above factors by means of an equation expression what is known as Stokes' Law. The greatest variable in this equation is the term relating to the size of the inclusion particle, because it occurs as the square of the radius of the particle, and the particle size thus assumes a most important role in the elimination of non-metallic inclusions. Fortunately, this is the factor most readily controlled by the proper choice of a deoxidiser.

Other factors that affect the extent of elimination of inclusions are : (*a*) The height of metal through which the particle must rise ; (*b*) the time between deoxidation and casting of the steel ; and (*c*) the ability of the slag to absorb inclusions, or conversely the ability of the inclusions to break through the slag-metal surface and be absorbed by the slag.

Convection currents in the furnace and ladle and mixing of the steel during tapping may also affect the extent of elimination.

Factors affecting Particle Size.

To produce large inclusions, it is necessary that the slags which form these inclusions be fluid at steel-making temperatures and have the proper surface tension, so that they may readily coalesce. Practically no data are available on the relative viscosities and melting points of many of the oxide systems.

Iron-Manganese-Silicate Slags.

A study of the melting points of the various combinations of oxides which may occur in liquid steel indicates that the system FeO-MnO-SiO_2 offers favourable conditions for the formation of large inclusions. Thus :—

(*a*) The lowest melting point of any combination of FeO and MnO (95 to 100%FeO) is about 2,500° F. ;

(*b*) The lowest melting-point of any combination of FeO and SiO_2 (78% FeO) is about 2,235° F.

(*c*) The lowest melting-point of any combination of MnO and SiO_2 (32% MnO) is about 2,245° F.

(*d*) The lowest melting point of any combination of FeO, MnO, and SiO_2 is about 2,200° F.

The foregoing shows that any method of deoxidation which results in the formation of a slag consisting of iron oxide, manganese oxide, and silica favours the formation of low melting point particles which readily coalesce and form relatively large particles which are rapidly eliminated from the steel.

Methods of Deoxidising Steel.

Three different methods of deoxidising steel may be employed to obtain inclusions of this composition :—

(*a*) *Deoxidation with Manganese followed by Silicon.*—When manganese is added to liquid steel containing FeO, it reacts with the FeO, and some MnO is formed. The FeO that remains after such an addition, and a portion of the MnO formed, will be dissolved in the liquid steel. Any insoluble oxides resulting from this reaction between Mn and FeO would be binary oxides consisting of MnO and FeO. If now a silicon addition is made, silica particles are formed which will immediately tend to be fluxed by the dissolved FeO and MnO and any insoluble binary oxides of FeO and MnO present in the steel. Hence, by varying the amounts of manganese and silicon added various slags consisting of FeO, MnO and SiO_2 slags consisting of FeO, MnO, and SiO_2 may be formed. Theoretically at least, it is possible by this method to obtain fluid inclusion particles which would combine with each other to form larger particles which in turn would be rapidly eliminated from the metal, but actual tests have shown that entirely satisfactory results cannot be obtained by this method.

(*b*) *Deoxidation with Silicon followed by a Manganese Addition.*—When silicon is added to a liquid steel containing FeO, particles of silica are formed whch are fluxed by some of the FeO present to form insoluble binary oxides of FeO and SiO_2. If, after deoxidising with silicon, sufficient FeO still remains in the steel so that some MnO could be formed by means of a manganese addition, some ternary oxide combination might also be formed. It is quite evident, however, that much difficulty would be encountered in attempting to form large fluid inclusions from this type of double deoxidation, because silicon is such a strong deoxidiser that there would be little FeO left for reaction with manganese, unless sufficient FeO had diffused from the slag into the metal to make the manganese-iron oxide reaction possible.

The results obtained by Herty and his associates on a number of open-hearth heats killed with silicon, followed by a manganese addition, show that large particles were not formed unless some iron oxide had diffused back from the slag into the metal. This method of double deoxidation can, therefore, not be relied upon to give a clean steel, and is inferior in this respect to the method in which the deoxidisers are added in the reverse order.

(*c*) *Deoxidation with Silicon-manganese Alloys.*—Complete deoxidation of a liquid steel by means of a suitable silicon-manganese alloy results in the formation of inclusions of binary oxides consisting of MnO and SiO_2. If the steel were only partly deoxidised with such alloys, some FeO would remain dissolved in the steel, which would flux with the manganous silicate in such a manner as to form ternary oxide combinations of FeO, MnO, and SiO_2, which have the desired composition and fluidity to form large inclusions.

While slags consisting of the three oxides, MnO, FeO, and SiO_2, may be produced by any of the three methods discussed, the last method is claimed to be the most satisfactory as a result of tests with both laboratory and commercial open-hearth heats.

Silicon-Manganese-Alloys for Deoxidation of Steel.

The work of Herty and Fitterer shows that not all silicon-manganese alloys are equally effective in causing relatively large slag particles to be formed. Alloys in which the ratio of manganese to silicon lies between 1 to 5 and 1 to 1, lead to the formation of inclusions similar to those formed when silicon alone is used. When alloys are used in which the manganese content exceeds the silicon content, larger particles are formed and there is a greater degree of elimination from the steel. The optimum results with a dead-killed steel were obtained by deoxidising with an alloy in which the ratio of manganese to silicon was about 4 to 1, with indications that a slightly higher ratio would be somewhat better. It was found impossible to dead-kill a steel satisfactorily using an alloy in which the ratio of manganese to silicon was about 9 to 1, but this alloy gave the best results of any tested in the deoxidation of a semi-killed steel.

A general conclusion from the results obtained on small experimental heats is that alloys with from 3 to 9 parts of manganese to 1 part of silicon will form large inclusions which are rapidly eliminated from the steel. Results on both basic and acid open-hearth steels, varying from 0·12% to 0·60% in carbon content, treated with silicon-manganese alloys, have shown that the best results were obtained when the ratio of manganese to silicon was between 4·5 to 1 and 6·0 to 1.

The Mechanism of Deoxidation and Formation of Large Inclusions.

The mechanism of the formation of these large particles involves several important factors, some of which are none too well understood. Upon the addition of silicon-manganese alloy to a liquid steel, it must first dissolve in the steel, and then manganese and silicon can react with FeO to form MnO and SiO_2. The SiO_2 is but slightly, if at all, soluble in liquid steel at ordinary steel-making temperatures, and so innumerable small globules of SiO_2 are formed. The MnO, on the other hand, is appreciably soluble, and no MnO particles will form unless its saturation point has been exceeded, which is unlikely in most steels. At this point each silica particle is surrounded with steel containing some MnO, and possibly a small amount of FeO, and it immediately starts to absorb the MnO and FeO dissolved in the steel to form a ternary oxide slag consisting of SiO_2, MnO, and FeO.

As this absorption proceeds, the silicate slag particles not only increase in size, but become more fusible and fluid, and collisions between particles are more likely to result in their coalescing than if the particles were of pure SiO_2. Hence, large inclusions are formed by these two processes—namely, the absorption of MnO and FeO by SiO_2 from the surrounding steel, and the accidental collisions of the particles. There is some evidence also which indicates that these fluid particles are attracted to one another by their surface tension relations.

Practical Applications.

As previously noted, the rate of rise of a liquid non-metallic particle is determined by certain physical factors in accordance with what is commonly known as Stokes' Law. The large particles formed on deoxidation with a silicon-manganese alloy of the proper composition rise in the steel bath at an extremely high speed compared with the speed at which small silica particles rise. The calculated maximum rising velocity of particles of different sizes and the time required to rise through 30 in. of steel, the average depth of the open-hearth bath, and through 12 ft. of steel, the average depth of a steel ladle, are shown in Table I. The importance of forming large slag particles is clearly shown.

Previous investigations made by Herty and Fitterer on the deoxidation of steel with silicon showed that the average size of the particles formed was 0·0006 in. In their work on the use of silicon-manganese alloys, much larger inclusions were formed. In an ingot which had been deoxidised with an alloy in which the ratio of manganese to silicon was 4 to 1, the average size of the largest inclusions was 0·04 in.

Table I. indicates that particles 0·0004 in. in diameter or larger formed on deoxidation would probably be eliminated from the open-hearth bath before a sample could be taken. It has often been noted in sampling large heats deoxidised with the proper grade of silicon-manganese alloy that samples taken 3 min. after the addition contained only a small amount of non-metallic matter, even though the steel was highly oxidised before the addition. In tests taken immediately after the addition, manganese silicates were found on top of the small test samples.

The importance of holding the ladle is also shown in that large inclusions would most certainly be completely eliminated from the metal if the ladle were held for 20 mins. If the ladle were held for 5 or 10 mins., these large inclusions would be well on their way toward the surface, and by the time teeming was completed, they would probably have been eliminated from the steel.

It is interesting to compare the rate of rise of the inclusions formed on deoxidation with these silicon-manganese alloys with the rate of rise of inclusions formed on deoxidation with silicon. Actual tests on the average rate of rise of the particles in ten open-hearth heats deoxidised with silicon showed this to vary from 0·15 to 1·5 in. per min. The large particles formed on deoxidation with the proper grade of silicon-manganese alloy have a rising velocity of 600 in. to 2,400 in. per min.—that is, from 1,600 to 4,000 times as great. It is evident from this that a steel deoxidised with the correct grade of silicon-manganese alloy should be a much cleaner one than a steel deoxidised with an alloy that does not cause the formation of large, rapidly rising particles.

While the greatest advantage in the use of silicon-manganese alloys lies in the type of slag particles formed, resulting in a much cleaner steel, this is by no means the only advantage. One decided advantage is that the recovery of manganese is uniformly high, so that the alloy cost is kept low and final manganese specifications are easily met. Due to the low melting-point and high concentration of the alloying elements in these silicon-manganese alloys the speed of reaction is high, and the temperature of the steel bath is increased with a consequent decrease in its viscosity. This favours the elimination of slag particles, and shortens the time of making an open-hearth heat, sometimes by as much as 15 or 20 mins. The complete deoxidation and increase in temperature of the steel which are obtained through the use of these alloys also aid greatly in obtaining a rapid and complete solution of alloying elements, such as chromium in the production of alloy steels. It is claimed also that there is a considerable improvement in the surface of blooms when the steel has been made with the use of silicon-manganese alloys.

TABLE I.
RATE OF RISE OF MANGANESE-SILICATE PARTICLES IN LIQUID STEEL.

Size of Inclusion, In.	Maximum Rising Velocity, In. per Min.	30 in. Open-hearth Bath, Min.	Least Time Required to Rise Through: 12-ft. Ladle, Min.
0·0002	0·06	493	2360
0·0004	0·24	122	587
0·002	6·12	4·39	23·60
0·004	24·45	1·22	5·87
0·02	612·00	0·05	0·24

Impressions of a Consultant Engineer on Tours of Continental Ferrous and Non-Ferrous Tube Works

By Gilbert Evans.

IN recording reminiscences of a series of tours of Continental ferrous and non-ferrous tube manufactories in the rôle of consultant, extending over a period of some eighteen years, mention must be made of the outstanding fact that, in almost all cases, the design of the layout and the working routine were founded, and extended with improvements on British methods, and, in addition, the main mechanical productive plants were of British manufacture. Going back to the beginning of the century, memory recalls that at that period a large percentage of present-day firms of world-wide reputation were in comparative infancy, and manufacture was carried on under cramped and ill-lit conditions in dingy buildings, with inadequate working floor space and little head room. Nightwork was carried on under bad lighting conditions which then existed. Such conditions are now happily but a memory, and, as already stated, for at least two decades British methods have provided improvements which have gained world-wide reputation and adoption.

Lasting impressions resulted from a first visit to the steel tube works of Messrs. Gio Ansaldo and Cie of Chertosa, Genoa, Italy, a concern comparable in size with some of our largest works. The spaciousness and airiness of the workshops caused much surprise. These consisted of six bays, each 610 ft. long, 70 ft. wide, and a height of 33 ft. 6 in. to the eaves of the roofs. Over the whole length and width of these bays not an obstruction was discernible, apart from the supporting rocf columns set at intervals of 36 ft. Each length of bay was traversed by a high-speed electric crane. During a lengthy stay the sources of ferrous material supplies were America and Sweden, while the equipment consisted of a hydraulic piercing press by Messrs. Fielding and Platt, Ltd., of Gloucester, supplemented by Pilger, and steam rolling mills by Messrs. Samuel Platt and Co., Ltd., Wednesbury, who were also responsible for bench installations.

It was apparent that one of the chief causes of trouble in manufacture was that of eccentricity of walls, a common failing where the hydraulic piercing process is adopted. It was not a difficult matter to trace this defect—the bane of the tube-maker—to the familiar source of sweating, and consequent loss of diameter, of the billets in the reheating furnace. It has always been necessary to roll the round billet to a diameter which, in reheating for insertion into the container, is increased just sufficient to slide easily into that receptacle. In the case under review the billet immediately on being put into the piercing chamber was submitted to full pressure of the main ram, an operation which compressed the material and eliminated side play. A tapered annular space was also formed by boring the bottom end of the container into which the billet was forced during the piercing operation, an improvement which considerably reduced the tendency of the piercing bar to bend while in compression. By the same method a saving in the weight of the scrap pad pushed out of the centre of the billet was effected. The piercing mandrels were of tough cast iron, and alternatively of malleable iron cast in chill mculds.

The draw benches were of varying design, but the results of chattering were shown by rings on the surfaces of cold-drawn tubes. The cause was definitely traced to be due to that section of the plant in which the tables of the benches were made from H girders bolted together at intervals, in comparison with the solid cast-iron tables usually adopted in British practice. The benches were tilted from the die-plate end to assist the return of the draw dogs to their starting position on the completion of the drawing operation.

Each department was a complete electrically operated unit. An unlimited supply of cheap power was available from the generating stations of the Alps, although at times such supply was restricted or entirely cut off, due to severe storms in the generating districts. To follow in sequence the routine of manufacture, the annealing furnaces were arranged for either coal or gas fuel, being 26 ft. long by 6 ft. to 8 ft. wide, the material for heat-treatment being transported by the overhead electric cranes, deposited on movable tables which were drawn into the heating hearth to emerge at the farther end for discharge at pickling boshes. These pickle and water boshes are of similar design to the British standard, but, instead of being built of timber, with tenoned and caulked joints and finished with heavy lead linings, the vats under review were hewn out of solid marble to inside measurements of 28 ft. long × 3 ft. 3 in. wide and 3 ft. deep. Such boshes are practically indestructible. A feature of the annealing plant was the side walls of the furnaces; these were continued on the discharge end at a height of 8 ft. to protect workmen in the vicinity from the heated atmosphere during the cooling-off process.

In the cold-drawing department the equipment consisted in the main of two 100-tcn and four 50-ton hydraulic benches by Messrs. Fielding and Platt, Ltd., complete with accumulator and pumps; nine 30-ton and 15-ton electrically driven chain benches. Various auxiliary tools, such as shouldering and tagging hammers, circular and band saws, tool and general stores, central works and departmental offices, and adequate laboratory research and testing facilities completed an up-to-date modern and comprehensive factory.

Societe D'Electro Metallurgie de Dives (France).

Reviewing my first, 1913, tour of the works of the Société d'Electro Metallurgie of Dives, about 16 miles west of the port of Le Havre, gives me special interest and pride. The company was closely connected with the then Leeds Copper Works, Ltd., now the Yorkshire Copper Works, Ltd., and was responsible for the first named British firm installing the Elmore process of manufacturing tubes by electrolytic deposition. They were also the first European company to install the Stiefel rotary piecer for the initial process of copper tube making, a process which in 1907 was adopted by the Leeds firm to the subsequent elimination of the electrolytic method, the chief weaknesses of which were unreliability owing to porosity and extreme softness of the deposited shell. The main object of this visit was to study the methods at De Dives in the casting of shells on sand ccres for subsequent finishing by cold-drawing into locomotive and condenser tubes for the British railways and Admiralty, and Admiralty contractors' specifications. At this point it is allowable to state that a corresponding visit by their technical staff with precisely the same object had been made to Leeds some years previously, and the methods then demonstrated had been considerably improved on in the intervening years. It was —from the economic point of view alone—interesting to find the firm manufacturing those expensive items, casting pots, in their own factory from their own clay mixture at the then cost of one franc and a half per pot, including cover, and that each pot's life was 600 k's. Each crucible carried about 78 kilos. of metal—about 171½ lb.

My data shows that after drying, and about ten days before being used, " the pots are dipped, outside surface

only, into a preparation of two-thirds ground silica sand plus one-third wood ash mixed with water, and are then dried on top of an annealing muffle until put into circulation. Just before being charged the pots are put mouth downward into the coke fire for a little while, and then raised to the heat of the furnace with charcoal and coke dust inside."

In the matter of design of the split moulds for casting the brass shell, great progress had been made, and the still prevailing British method of slightly slanting swing split moulds had been entirely replaced by perfectly vertical moulds standing on circular feet. Allied to this development was the central pourer in place of the spout pouring which still exists in home brass-tube foundries. The apertures of the pourers, which consisted of holes in the bottom of a basin fixed on the top of the moulds, were in the ratio of 4% to the total circular area of the cast shell wall. This design eliminated the cooling of the two halves of the moulds between pouring of casts which still obtains at home. The furnace aperture was 400 mm. × 400 mm. square by 1,000 mm. deep, and in practice there was always a thickness of 150 mm. of coke between the bottom of the crucible and the fire bars. Moulds were cleaned between each cast as follows :—

1. Both halves well scrubbed with wire brush made of file card.
2. Joints scraped with piece of flat steel.
3. Brushed with soft brush over all parts.
4. Fine dust blown out with hand bellows.
5. Finally, casting surfaces dressed with a preparation of ½ kilog. linseed oil, ½ kilog. animal fat or lard, stiffened with blacklead (powdered). This mixture was kept at a low temperature in a covered tub and applied to the moulds with a half-pound paint brush.

Care was taken in charging the crucible, so that each ingredient was thoroughly molten before adding the next—for example, copper, spelter, tin, in the order named.

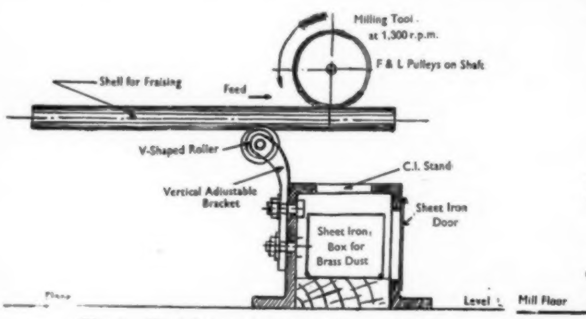

Fig 1—Fraising tool for cast brass shells

After stirring with a charcoal stick, an indication that the alloy was ready for pouring was a shaking movement imparted to the stirring rod by the movement of the spelter. All small scrap from various sources is worked into ingots before being used for brass shell castings, a method which reduces oxidation loss considerably.

For the removal of the slight flashes left on the cast shell by the joints between the top and bottom halves of the moulds, a simple milling tool had been evolved, (Fig. 1), being belt driven on to fast and loose pulleys, the spindle being adapted for a milling or cutting tool at each end. The cutter revolves on to the shell to be dressed—which is supported on a free-running V roller—in the direction away from the operator. No power is required on the operator's part, except sufficient to keep the shell in contact with the cutting teeth of the tool, while its revolutions practically supplied the feed for the travel of the casting. As arranged, two operators can be employed on each spindle.

In the cold-draw bench department a high state of efficiency existed in the design of the benches, the process of drawing at chain speeds adapted to varying diameters and thicknesses of walls of the shell, and use of lubricants. Drawing grease obtained from Isaac Holden, Bradford, and "Suisitine" from Croix, Nord, France, was used on all classes of tube for all passes except the finishing pass, when soap suds from ordinary domestic soap is used for outside and inside. The soap was dissolved and kept in a bosh at the side of the benches, the tubes being dipped in just before drawing. Very light drafts were given in the final pass—*e.g.*, from 15 × 17.1 mm. to 14 × 16 mm., removing .05 mm. all round the wall.

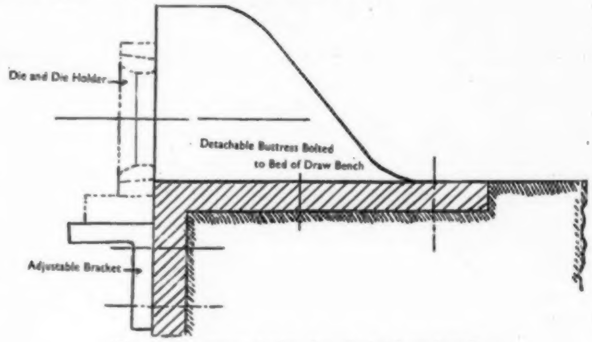

Fig. 2—Buttress design for chain draw bench.

The general design of the chain benches were in keeping with those standardised by British manufacturers, one of the most striking departures being that of the buttresses which support the die-holders and which take the full load of the pull on the tubes, which are cast separate and bolted to the main bed of the bench, allowing in case of breakage an easy replacement, (Fig. 2). British practice is to cast the back length and buttresses in one piece, and as breakages do occur, it is necessary to patch or to replace the whole back section—an expensive repair.

In the design of the drawing dog or carriage which engages the tube and chain, a lever attachment governed the gripping jaws, making the trapping of the operator's fingers impossible. All light benches are operated by one man, and are arranged with a fall of 2½ in. toward the die-plate end, so that on the completion of the drawing operation the dog is returned by gravity to a position ready for thenext pass. Its return speed is governed by a wire rope

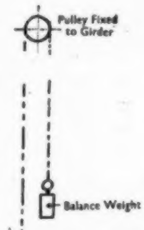
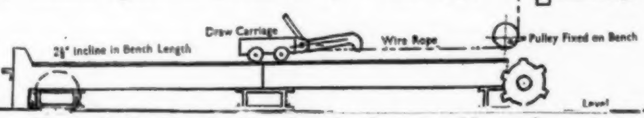

Fig. 3—Inclined bench table. Drawing dog returned by gravity.

attached to the carriage body by an eyebolt, the rope passing under a pulley at the sprocket-wheel end of the bench and thence over a pulley attached to the roof girder. A weight is attached to this free end of the wire, its weight being a little under that of the dog (Fig. 3). A pulling-up arrangement at the back end of the mandrel stem enables the drawer to pull his mandrel into correct proximity with the die without leaving his work. This consists of a loose plate sliding on four horizontal rods. Attached to the plate is a swinging lever operated by the workman by means of a ⅝ in. rod. Horseshoes of varying thickness dropped over the mandrel holding rod govern the position of the interior mandrel head in its relation to that of the exterior die. The reduction of the area of the shells in various stages varies from 30% to 35%, and where the strength of the material allows it, never less than the latter figure.

It is necessary here to remind the reader of the date of this tour, and noting the progressive policy of the firm under review, it is decidedly probable that further modernisation of their appliances has been evolved. The forward trend was always in evidence, as in the case of British manufacturers, where automatic appliances such as automatic furnace charging and discharging machines have replaced manual labour.

The study of methods by which annealing in bulk was accomplished was one of the chief objects of the visit of inspection, and what impressed was the general arrangement of the furnaces relative to which one's data refers as :—With the overhead cranes hand work is reduced to a minimum : the material to be annealed is loaded to an average weight of 5 tons on three bogies coupled together, and drawn into the heating chamber by means of a chain. The time for annealing this weight varies between 2½ and 3 hours. When annealed, the bogies are drawn out by chain power, and after standing for varying periods, copper bands are passed under the annealed material, and hooked up to a frame suspended from crane : the whole load is immersed in a pickle bath for about 4 or 5 mins., lifted out, slightly drained, and then dipped into water bosh and swung about until all oxide, etc., is removed. If the work is of one size it is then taken direct to the bench, where next pass is given. If mixed load as we saw, it is put down in a general assembling place, and after draining taken in bundles to the various benches. The whole operation of annealing and pickling is a most effective one, leaving the outside and inside very clean. The dimensions of the pickle boshes (lead-lined) are 1,300 mm. wide, 765 mm. deep, 7,000 mm. long ; they are built into the floor, the combing standing 175 mm. above floor level. The lifting bands are of copper, 140 mm. wide 3½ mm. thick, 3,450 mm. between loops (Fig. 4).

All copper shells from the piercing mill are put into hot pickle before being put on bench for drawing ; they are not boshed at the machine after piercing.

Brass shells of 70/29/1 quality are bored and turned from 84 × 54 to 82 × 57 and annealed and pickled after this machining before being put on the bench for drawing. All other classes of work are put on for drawing without annealing.

Finspong Metallverkes A.G.

In relation to its population, Scandinavia, with its three empires—Sweden, Norway, and Denmark—has developed into one of the most progressive areas of Europe. Vast non-ferrous manufactories are to be found at Finspong in the province of Ostergotland, which lies 30 kilometres from the town of Norrkoping on the direct main railway line from Malmo to Stockholm. Further north, and near to Stockholm, the works of Svenska Metallverkes A.G. at Vasteras have been enormously developed since its inception. The author enjoyed a visit extending over a period of three months to the Finspong works, in connection with the installing of his rotary piercing machine, which plant had a capacity for dealing with solid copper billets from 2 in. up to 9 in. diameter, and thence by the supplementary expandings up to 20 in. A part of the national policy in the development of trade is to apply as much as possible of its own products in the equipment of the factories, and the electrical equipment for operating the mill in question, consisting of two main motors, each of 250 n.h.p., with an overload of 100% for 45 secs. every 2 mins., an 8 h.p. reversing motor governing the setting of the main working rolls, together with starting and switchgear panels, and connections were supplied by the Asea Electric Co., Sweden. The body of the mill and all operating components were supplied by Messrs. W. H. A. Robertson and Co., Ltd., Bedford, England. The tube mill, consisting of the piercing plant, hydraulic and chain benches, adequate annealing furnaces, pickling boshes, and supplementary tools, such as tagging hammers, circular and band saws, made up the complete unit in one vast span and under the same roof. This huge department was traversed by high-speed electric cranes capable of handling the whole of its transport. On the extrusion side, vast strides had been made, and at the time of one's visit in 1928-29 it was demonstrated that the horizontal press had been entirely superseded by the vertical type, a reference which applies, of course, only to tube-making.

Of peculiar interest was the adaptation of a heavy double-geared deep-drawing vertical power press by Taylor and Challon, Ltd., of Birmingham, for the extrusion of smaller sections. This tool was capable of delivering in a working shift of eight hours a total of 9,600 ft. of tubing, and one could not help being impressed by the remarks of the chief engineer to the effect that " some firms are starting experimenting at the place we left off at some thirteen years ago."

Exceptional attention was given to the preparation of the solid billet before extruding, the outside surface being machined, and a hole bored through, or part way through, its length to ensure concentricity in the wall of the finished cold-drawn product. Preparations to complete the several processes on a straight-through system, free from covering the same ground more than once were under way, which included the solid billets being delivered down a sloping way, direct to the rotary mill from the casting shop, where electric furnaces were exclusively operated.

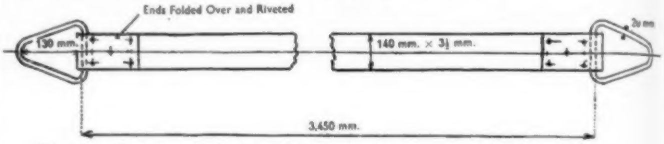

Fig. 4 —Copper rands for lifting tubes to and from pickling bosh.

This brief review will serve to indicate the thoroughness with which every step in manufacture has been studied and put into practice. In other branches of the non-ferrous trade, such as plates, sheets, rods, and wire, similar effective methods were applied, and it was a matter of interest to learn that immense quantities of high conductivity wire and other finished non-ferrous products were regularly supplied to Ireland. Admirably situated geographically, the Finspong Metallverkes generate their own electric current from water power, and also supplies lighting for the houses of their employees, the bulk of whom reside in the immediate vicinity of the factory. In concluding this brief review of the Finspong works, and diverting from actual manufacture, one pays tribute to the arrangements made for the visitors' comfort, in the form of a large hostel, complete with sleeping and dining accommodation, together with lounge, study, and writing rooms—a most acceptable factor in a country where in the smaller towns hotel life as we know it in England is practically non-existent.

Porsgrund Metall. A.S. Norway.

The non-ferrous factory of the above-named company is situated about 19 miles south of Oslo, near Skien, and on one of the bights of the numerous fiords which abound in that region. Other manufacturing businesses in the vicinity are engaged in shipbuilding and wood-pulp making, the whole employing the bulk of a population of 9,500 inhabitants. The firm under review confine themselves almost solely to tubes, rods, and the like, of copper and alloys embracing aluminium, and all brass mixtures, for the manufacture of which they are admirably equipped with electric melting, reheating, and annealing furnaces. The main sources for the supply of shells for finishing into cold-drawn tubes are a Mannesmann cross-roll type of rotary piercing mill, and horizontal and vertical hydraulic extrusion presses, the latest of which was to Serck's (Birmingham) patent, built by the old-established firm of Fielding and Platt, Ltd., at Gloucester, England. The cold-drawing plant includes chain benches of varying strengths and chain speeds adapted for material for different diameters and wall thicknesses, each bench being a separate motor-driven unit. Transport and handling are accomplished by a series of cranes, and in the layout of the factory due attention has been paid to the important factor—ample working space with continuity and directness in the various stages of manufacture. A fine service of a combined research, technical and practical staff, under a central management board control, direct the operations of this progressive firm.

METALLURGIA

The British Journal of Metals

Contributions suitable for the editorial pages are invited. Photographs and drawings suitable for reproduction are welcome. Contributions are paid for at the usual rates.

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METALLURGIA

THE BRITISH JOURNAL OF METALS.

1933–34.

It would be distinctly unwise to view the improved conditions in this country with too much optimism, as they are still far removed from what were once considered normal, but it must be recognised that they are a good deal better than they were at the end of 1932. Apart from the first month or two, there has been a steady improvement during 1933, the most encouraging feature of which has been its widespread character; practically all the industries have benefited and it is difficult to single out any one industry as being more outstanding than another in this respect. The most important evidence of improvement is undoubtedly the increased number of people who have found employment. It is this that gives the surest indication of returning confidence because it means that the demand for products has increased, necessitating further labour assistance to meet requirements. The number of persons employed has increased very steadily throughout the year, and the unemployment figures have been reduced by over 600,000.

There has been nothing spectacular about this improvement—which is also indicated by healthier prices, increased railway receipts, and improved revenue—it has been achieved in a manner that is typically British; yet only about six months ago it was confidently asserted that recovery depended upon satisfactory solutions to world problems which were only possible through the World Economic Conference.

In reviewing the trend of improvement in 1933 it would be futile to overlook the influence exerted by the increased home demands resulting from the import duties. These have had a very important effect in encouraging the renewal of industrial activity. It will be appreciated, however, that this country particularly, cannot be permanently prosperous excepting through a healthy international trade, and, in the world's markets, recovery is more difficult to assess than the condition at home. International trade does not necessarily follow the expansion in internal trade and tariffs, quotas, exchange restrictions, and fluctuating currencies hamper the exchange of goods and manufactures. But, even in international trade, a definite improvement is recorded. Our share in the world's export trade has increased. During 1932 the United Kingdom's share amounted to about 10% of the international trade and occupied the third most important position as an exporting country—the United States and German exports exceeding ours in value. A steady expansion in the value of our exports during 1933, however, changed this position, and for the six months ending with September this country held the first place.

The departure of the United Kingdom from its traditional policy of free trade had the inevitable result of approaches from many countries desirous of revising their trading agreements. Most of the approaches were from European countries. Several new agreements have been concluded during 1933, namely, with Denmark, Norway, Sweden, and Finland. Negotiations are in progress with the Soviet Government, with the Baltic States, Latvia, Lithuania, and Estonia, and may shortly be expected to materialise. Soon also a new agreement with Poland may be set up. The agreements already made and ratified promote better facilities for the exchange of commodities and manufactures between the countries concerned, and are bound to have an increasing influence on improving trade with the gradual restoration of confidence. Some progress during the last year is also recorded with our self-governing Dominions and with improving conditions in these countries we may hope that this trade will expand.

It is significant that all the basic industries show signs of improvement, including coal, iron, and steel, engineering, and even shipbuilding looks as though the worst of the long depression is past. Probably the most improved of these is the iron and steel industry, in which pig-iron production has increased by about 15% and steel by about 33%, to totals of approximately 4,000,000 tons and 7,000,000 tons, respectively. During the year the number of furnaces in blast have increased from 60 to 80, and there are indications that further furnaces will be necessary to meet the growing needs. This upward trend has been apparent since the Government recognised the economic importance of this industry and afforded it some degree of protection. Since that decision was put into execution there has been a growing confidence amongst iron and steel manufacturers regarding the future of their industry, which is apparent from the developments in progress, notably of Messrs. Stewarts and Lloyds, at Corby, and of Messrs. Guest, Keen and Nettlefolds, at Cardiff, of the English Steel Corporation, at Sheffield, to mention only a few.

Encouraging as the improvement is in the iron and steel industry, it must be pointed out that the production of pig iron and of steel is still substantially below the output reached in 1929 when the figures were 7,590,000 tons and 9,640,000 tons, respectively, but, if the remarkable improvement continues, we may reasonably hope to see the figures for 1934 make favourable comparison with those for 1929. Certainly, there is a confident feeling that 1934 will witness a further all-round improvement.

The announcement that the National Federation of Iron and Steel Manufacturers has reached agreement with the inter-dependent steel industries of Germany, France, Belgium, and Luxemburg, has an important significance. The object of this agreement is to stop uneconomic competition in the supply of steel plates for shipbuilding. What is aimed at is a division of markets and a rise of 10s. per ton in the prices charged by the European cartel. Actually, this will be of great benefit not only to British steelmakers but also to British shipbuilders, because shipbuilders in markets outside the cartel have been able to obtain their steel at lower prices and thus undercut British builders. Under the agreement competition will cease, and we understand one of the conditions to be that the United Kingdom and all Empire markets for this class of material will be reserved for British manufacturers.

The outlook for this year is certainly more hopeful than at the beginning of 1933, and order books are in a much healthier condition. Even the shipbuilding industry, which has been probably the hardest hit of any during the slump, shows encouraging signs, and there has been a steady demand for new tonnage. This, together with the undertaking that the Government will give financial facilities for the completion of the big Cunarder, is putting new heart into industry. There are, however, many economic problems to be solved before this country can enjoy the benefits of her enterprise; world conditions are still far removed from normal and many countries are still in a state of bankruptcy, but providing there is no international setback we are justified in believing that conditions will gradually improve.

RESEARCH AND INDUSTRY.

THE rapid development of the social structure of the civilised world is due, in no small degree, to the application of the results of research. In all the various branches of commerce and industry necessary to the maintenance and preservation of life, investigations are continually in progress with a view to the further development of old industries, and, by means of new inventions, establishing new means for meeting the requirements of mankind. It is this continual striving after improvements to increase the material resources of the world for the benefit of mankind that is the duty of the research worker, and the measure of success achieved is to a large extent the measure of progress.

In order that British research work would be progressive and of definite assistance to industry, the Government established a £1,000,000 fund in 1917 to encourage the establishment by industry of associations for research. According to the report of the Advisory Council of the Department of Scientific and Industrial Research, which has just been published, this fund is now exhausted, and grants are now being made from its Parliamentary Vote. A considerable part of this report is devoted to a review of the scheme inaugurated and developed by means of the fund and to a consideration of the lessons to be drawn from the experiment.

It was realised during the war that on the conclusion of the conflict a situation would arise in the world of industry which would call for increased effort to maintain British industrial progress. After careful consideration it was considered that the most effective way of promoting this aim was by means of co-operative research associations, and a scheme on these lines was instituted. The scheme visualised the formation of national research organisations to stand behind and supply, with new ideas, new methods, new standards of quality, the principal industries of a nation dependent for its very existence on its power to feed itself by means of the sale of its manufactured articles.

To achieve success it was felt that the research associations must be intimately bound up with the industries concerned, be organised by them, managed and controlled by leaders appointed by them, and must reflect throughout all their operations the spirit that animated them. So organised, there was real hope that the results achieved by the research associations would be utilised by the firms that subscribed to their support, and that in due course the utility of the organisations would be proved.

As an outcome of the changes resulting from the adoption of the scheme, there has been a definite acceleration in the advance of industrial science, and the research organisations have made important contributions to that movement. The share contributed by the associations is appreciated and recognised by those intimately concerned with industrial progress, and can be appraised accordingly, although it is impossible, as a rule, to assess it in terms of £.s.d. By the dissemination of up-to-date information in regard to developments in the scientific fields concerned by means of efficient intelligence bureaux, in assistance with the more immediate problems confronting industrial firms, and, above all, in the opinion of the Advisory Council, in the continuous study of root problems, the associations have played, and will continue to play, an important part in the progress of industry. To those who are in a position to realise these changes it is unnecessary to quote concrete examples, and difficult to do so in terms which can be appreciated by all. But, even so, achievements by research associations can be quoted that seize the imagination of everyone. In some cases the estimates are of value realised, and in others they are based on savings which will only be possible when the results can be fully utilised.

The Council quote with some degree of pride a few results that make insignificant the cost of their attainment. A few years ago it was computed on reliable authority, after full investigation, that the annual savings which have accrued from the work of the Electrical Research Association through researches costing at that date £80,000, amounted to no less than £1,000,000 a year, a figure which must have been materially increased since that time. The Cast Iron Research Association has conducted investigations which, if fully adopted, would result in a saving of fuel and other economies amounting to £200,000 per annum, besides producing a range of heat-resisting iron alloys of great importance.

The Iron and Steel Industrial Research Council, one of the more recently established co-operative organisations, has completed research work, the full appreciation of which it has been calculated on a basis of production in 1930, would result in a saving of about £392,000 worth of coke used in the production of pig-iron and in the production of finished steel, a saving in coal of no less than £1,341,000.

The Non-Ferrous Metals Research Association has made outstanding advances, and we will mention two only—the work on new ternary lead alloys used in the sheathing of cables and for water-pipe service; and that on aluminium-brass for condenser tubes with its corrosion resistant properties. The Refractories Research Association has been able to make suggestions which have had the effect of prolonging the life of some types of saggars (the fire-clay boxes in which pottery is fired) from 7 firings to 200 firings. The estimated annual expenditure on the replacement of saggars is £200,000.

It is further stated that the fund has attracted a total industrial contribution of £1,750,000, and that at the moment the State is contributing £65,000 a year and industry £170,000 towards the support of a group of 19 research associations, which include in their membership some 5,000 firms covering a field of manufacturing industries providing about 50% of the exports of the country.

The conditions to-day, so far as can be judged, appear favourable to a strong forward movement on the part of British industry, and it is hoped that manufacturers will recognise the opportunity that lies before them and will see to it that the research associations of which they may justly feel proud are given ampler opportunities to serve them. We observed with pleasure the remarks made by the leading bankers of this country in their last annual addresses to the effect that scientific research had to find a more prominent place in industrial endeavour, and we hope that such observations endowed with the authority of those financial leaders will serve to reinforce the views we have so often expressed. The methods and processes of yesterday will not suffice to-day or to-morrow, and one of the ways in which the British industrialist can maintain his name and reputation for quality is by active participation in scientific research into materials and processes which will pave the way for further advances. Science is destined to play an increasing part in industrial production, and those who fail to learn that lesson will inevitably find themselves relegated to an inferior position.

According to the report the Council have no hesitation in saying that the scheme inaugurated 16 years ago has justified the faith displayed, and the money expended upon it both by the State and by the industries themselves; but unless increased expenditure is incurred and the scope of the operations of the associations widened thereby, there is considerable danger that the opportunity they afford will be lost, and British industry will not be assisted to the degree and in the directions it needs to be. Especially is it desirable to see the deep-seated scientific problems of industry attacked with assiduity, for on researches of this nature the future welfare of British industry will largely depend. The Research Associations, and all they stand for, are still in their infancy; they have grown to no adequate stature as yet, and their one great lack is sufficient income. The promise is there, the men with scientific attainment are available, the opportunity is great, and the time for development ripe; all that is necessary is support commensurate with the importance of the industries embraced.

Correspondence

Reducing Nitrided Die-Steel Costs.

January 6, 1934.

The Editor, METALLURGIA.

Sir,—I was extremely interested to read the article in your December issue by Mr. Glyn Powis on "Reducing Nitrided Die-Steel Costs." There is, however, one point to which I would like to draw attention. This is the question of procedure for machining and hardening nitralloy steel prior to nitriding.

Your contributor recommends that working surfaces are machined to within 1/16 in. of final dimensions prior to the preliminary heat treatment, stating the blocks are more easily machined in the annealed condition. The latter statement is, of course, quite correct and will be readily accepted. As dies, however, are invariably made from Grade I. of nitralloy steel, which in the oil-hardened and tempered condition may have a tensile strength of approximately 90 tons per sq. in., considerable difficulty is experienced in removing the final 1/16 in. after heat treatment. In fact, on three separate occasions, for different machinists, the writer has oil-hardened and tempered nitralloy dies in the manner suggested by Mr. Powis, and in each case it has been impossible to complete machining without the aid of an additional annealing operation. In view of this experience one concludes it is much better to adhere to the procedure recommended by the patentees of the process, and also the manufacturers of the steel.

The sequence of operations recommended is :—(1.) Machine and finish impression. (2.) Oil harden and temper (cover impression with charcoal). (3.) Slight sand blast. (4.) Nitride.—Yours, etc.,

Bradley & Foster Ltd., Darlaston, Staffs. J. H. D. BRADSHAW.

January 12, 1934.

The Editor, METALLURGIA.

Sir,—I am delighted to see that my article on "Reducing Nitrided Die-Steel Costs," published in December issue, has attracted the attention of Messrs. Bradley and Foster, of Darlaston.

In answer to their letter, I think that if I had given greater detail in connection with my preliminary heat-treatment of the die-blocks it would have been better than taking it for granted that such procedure was well known.

As Mr. Bradshaw has omitted to mention his tempering temperature, it is presumed that he has adhered to the usually recommended 500° C. for that operation. If this is so I can well imagine that the machinists following would experience difficulty in removing the final 1/16 in. I, myself, as a fairly extensive user, met quickly with this difficulty some three years ago, but, as I also found that the removal of a final 1/16 in. prior to nitriding appreciably increased the resultant life of the block, I was determined to overcome the difficulty although keeping in view my desire for a core tempered at not more than approximately 500° C.

This I eventually accomplished by tempering first of all for one or two hours (according to mass) at 500° C. I then rush the above up to 575° C. to 600° C. (again according to mass), and hold at the latter stage for 10 to 15 mins. By this means only the outside skin, or layer, of metal has time to attain the higher temperature, and after its removal, which the above treatment renders considerably easier, the core remains with a hardness equal to the lower temperature and calculated to give the better result accordingly. Of course, it is obvious that an open muffle type stove will not suffice for this; only a molten-body contact can accomplish the quick change demanded.

As regards the sand blasting usually advocated, not all die users have the necessary equipment, and advocation of same may render it necessary to send the tool away for that purpose, being returned afterwards prior to nitriding, as most people desire to view their own die impressions before gasification. This causes still further delay to an already lengthy process, and as the object of my article was to encourage other die-block users to try nitrided blocks, I regret my experience does not agree with Mr. Bradshaw's in regard to sand blasting being superior to my own method outlined above for removing that last surface prior to nitriding, taking into consideration the relative results obtained. It is admittedly the easier way, but the user is generally out for maximum life, and when the die needs to be away for the greater part of a week for the nitriding process, he may just as well go to a little extra trouble in the preliminary treatment in order to increase the possibility of a greater production from same.

Nevertheless, I thank Mr. Bradshaw and his firm for their interest in the matter, and hope they will continue to nitride the blocks I send them as successfully as hitherto.—Yours, etc.,

GLYN POWIS.

Wear Results on Cylinder Liners.

THE most consistently successful results on cylinder wear have been obtained by the use of oil-hardened and tempered (chill) cast-iron liners, said Mr. T. R. Twigger in a paper read before the Preston Branch of the Institute of British Foundrymen. On an average, the various tests which have been carried out have resulted in 100% longer life when used with centrifugally (chill) cast-iron piston rings, and even better results are obtained by the combination of hardened and tempered centrifugally (chill) cast-iron liners, and hardened and tempered centrifugally (chill) cast-iron piston rings, as is illustrated by the following authentic figures :—

A recent report on hardened and tempered cylinder liners used with hardened and tempered piston rings in a Diesel engine for road transport work, indicates that the wear ranges from 0·0003 in. to 0·001 in. per 10,000 miles. The lower figure is equal to 33,000 miles per 0·001 in. cylinder wear. It is stated that wear is always confined to a very small portion of the liner near the top of the stroke, no wear being detectable in any other part after 40,000 miles of running.

In another case, a petrol engine, also used for commercial-vehicle work, fitted with hardened and tempered liners, and hardened and tempered piston rings, showed after 100,000 miles, a wear equivalent to 12,500 miles per 0·001 in. in cylinder-bore wear. An advantage of hardened and tempered centrifugally-cast liners over materials having only a superficial surface hardness, is that, being uniformly hard all through, they can be reground so as to obtain a further life, should this be desired.

Bearing Metals.

THE subject of bearing metals was discussed by Mr. A. J. Murphy at a recent meeting of the Manchester Metallurgical Society, in which he traced the development of suitable alloys and their functions. White metals and bearing bronzes, he said, have developed along almost entirely empirical lines, but the researches of Hardy on boundary lubrication may provide the foundation for an understanding of the principles on which the functioning of a bearing metal depends. Under the influence of friction the chemical activity of metal surfaces appears to be enhanced, especially in relation to lubricants. Adhesion to the shell is an important factor in the endurance of white metal linings ; Stanton's ring-fatigue test gives results analogous to the effects observed in service.

Among white metals the tin-base alloys are superior to any of the cheaper alloys which have been produced, including those consisting of lead hardened by alkali metals, and zinc-base alloys. Copper-lead alloys, applied as thin linings in steel shells, have been extremely successful in special applications where white metal linings fail by cracking. Cadmium-base bearing metals are highly resistant to wear, but special methods are necessary to secure an adherent lining. Porous bronzes, produced by a type of sintering process, can be made "self oiling," and are useful for lightly loaded bearings. Mr. Murphy described various types of bearing testing machines.

The Micro-optical Investigation of Iron and Steel by Polarised Light*

By N. Ahmad, B.Sc., D.Sc.Tech.

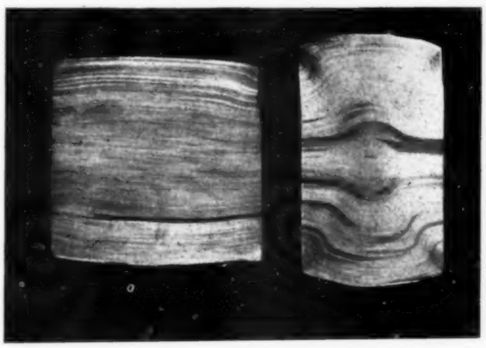
In collaboration with

Professor D. M. Frh. v. Schwarz (Munich).

In this work attention has been directed to the examination of iron and its alloys by polarised light; various structures have been examined, and their behaviour from cold work and deformation has given valuable results. The systematic survey of various etched specimens, with different heat-treatments has revealed an accurate method of distinguishing the structures, which govern the mechanical properties of the material.

THE application of polarised light to the study of iron and steel deformed in the cold state has revealed that the right direction of the work can be definitely decided under cross nicols. This is more easily accomplished when the material contains pearlite.

The knowledge of the direction of cold work is considered to be necessary for the most intelligent use of the material to various purposes, for their proper processing and inspection during working, such as rolling, forging, and drawing, which have recently attained a very important



No. 1. No. 2.

Fig. 22.—Cold compressed steel pieces, showing phosphorus segregations deformed by compression.

place in engineering practice. The new method of making screws and bolts by cold deformation, which has been proved to be very successful, is based upon the directional characteristics of crystal grains.[19] The examination of such screws and bolts has shown that at places where there is even a slight deformation, and the work direction of which cannot be rightly judged by an ordinary microscope, show a clear directional phenomenon under polarised light. The direction of crystal grains in cold-worked aluminium plates has already been referred to by Professor D. M. Frh. v. Schwarz.[20] In the case of iron and steel, this extraordinary phenomenon has also been discovered.

When a piece of cold-worked steel is placed under cross nicols and the disc is rotated, the pearlite grains are brightened only when the direction of crystal deformation makes an angle of 45° to the direction of polarised light entering into the microscope. At all other places the grains are quite dark.

In Fig. 22 are shown two pieces of steel, No. 1 and 2, cold compressed by 38 and 30 tons until the height was reduced about 45 and 40% respectively. The surface of the pieces is etched macroscopically with a solution of copper ammonium chloride, showing phosphorous segregations, deformed by compression. In Fig. 23 is shown a section through the piece No. 2, polished and etched with 1% HNO_3 and photographed under parallel nicols. The direction of the work is at 45° angle with the direction of light. The same structure at the same position is shown under cross nicols in Fig. 24. The pearlite grains are quite brightened, and are more clearly seen, giving a better idea of their direction. The results are greatly improved by further inserting red I.O. Nicols being crossed, the disc is rotated through an angle of 45°, so as to make it parallel to the direction of light. The structure is perfectly darkened except at a few points. This is seen in Fig. 25.

In the case of screws and bolts manufactured by the new Nussbaum's method, the direction of work plays a great part. The strength of these screws is much decreased by the unsuitable direction of crystal grains, and often they actually fail in work. The employment of the polarisation microscope has provided a valuable method for the proper examination of the structures, and has proved successful where other methods have failed.

The authors have investigated the structure of various screws and bolts of different size and shape manufactured by the new method, under polarised light. It was found that the direction which is indicated by sulphur prints, or by etching with various reagents, may not be the right direction of deformation. Fig. 26 shows a sulphur print of the head of a screw made by double cold pressing. The

19 Rohe Schrauben, Bauer u. Schaurte Neuss.

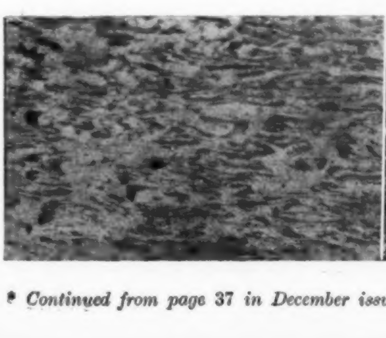
20 *Zeitschr f. Metallkunde*, 5, 1932, p. 5.

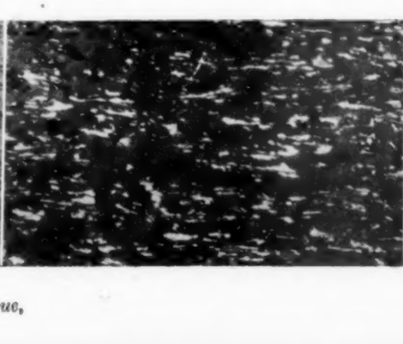
Fig. 23.—Microphotograph of specimen No. 2, shown in Fig. 22 under || nicols × 90.

Fig. 24.—The same as in Fig. 23 under + nicols × 90.

The direction of the specimen is at 45° to the direction of light. The pearlite grains are brightened under + nicols.

Fig. 25.—The same specimen seen after inserting red 1·0; with + nicols the disc is rotated through an angle of 45° to make it parallel to the direction of light.





* *Continued from page 37 in December issue,*

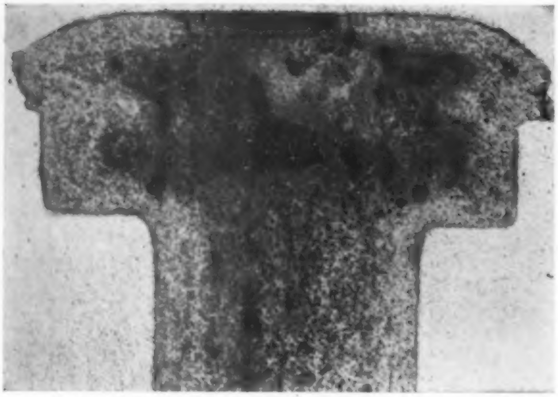


Fig. 26.—A sulphur print of a steel screw head after double cold pressing × 2·5.

same portion is shown in Fig. 27, etched with 2% HNO_3. The direction of work as it appears in these illustrations can be compared with Fig. 28, drawn as seen under polarised light. It will be noted that the right direction as seen in this illustration is not shown in either Fig. 26 or Fig. 27. The results of these experiments may serve as a guide to the actual phenomenon of polarised light.

It is seen that the direction of the structure resulting from the application of cold work makes a definite angle to the direction of light entering into the microscope, and the structure is brightened. This proves that there exists a definite relation between polarised light and the direction of pearlite grains, or in other words, the reflection of polarised light from pearlite elevations which can pass through analyser is closely related to the direction of vibration of light.

Some Foreign Inclusions in Iron.

Titanium Nitride.—The presence of titanium is often noticed in cast iron. Due to its great affinity to nitrogen,[22] it forms titanium nitride, which is insoluble in the iron. Its appearance under microscope is in the form of angular crystals in unetched specimens.[23] The colour of such crystals is mostly a red tint, but sometimes, due to overheating, it exhibits a dark-brown tint. Although its occurrence is important in iron since it has a great influence upon the mechanical properties, particularly on the resistance of iron to deformation,[24] its presence is seldom observed under the ordinary microscope. This is due to the small size of its particles. By the application of polarised light, the minute crystals of titanium nitride can be discovered at once in the iron slides. Fig. 29 represents a micro-photograph of a burnt cast-iron unetched specimen, showing an angular crystal of titanium nitride under parallel nicols. The same specimen, photographed when the nicols are crossed, is shown in Fig. 30. In the latter case the crystal is very bright owing to double refraction, and if the stage is rotated it becomes completely dark twice in a half rotation. The presence of this substance is thus easily detected when polarised light is used.

Another interesting structure incidentally observed is the eutectic structure of MnS–MnO. This structure was first studied by Rosenhain. According to the equilibrium diagram,[25] this eutectic is formed at 50% MnS. In cast iron containing a sufficient quantity of Mn and sulphur, it is

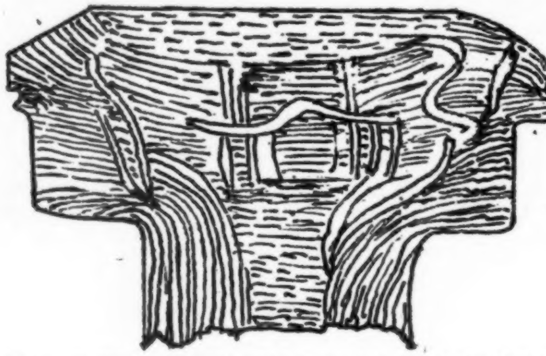


Fig. 28.—The direction of the work applied to the screw head, shown in Figs. 26 and 27, drawn as seen under polarised light.

often formed by oxidation at a high temperature. A microphotograph of an unetched piece of cast iron burnt at a high temperature is shown in Fig. 31, which contains this eutectic. It lies near the MnS particles, and its structure is not so clearly seen with parallel nicols, but with cross nicols, as in Fig. 32; it shows a beautiful reflection effect, and the colour changes four times from red to yellow by the rotation of the stage. The structure is more clearly seen by the use of red I.O.

Graphite and Temper-Carbon.

A large amount of work has been directed on the study of graphite under polarised light, and it is found that the presence of carbon either in the form of flakes or temper carbon can be thoroughly examined by means of the typical polarised effect produced under cross nicols.

Natural graphite has long been recognised as an anisotropic substance, with a definite crystalline form of carbon, belonging to the hexagonal system.[26] Its behaviour under polarised light is also known in mineralogy.[27]

Recent investigations under X-rays have proved that graphite present in iron as flakes or as temper carbon is simply a modification of natural graphite.[28] The only difference being in the shape and size of crystals. The

22 Oberhoffer. Das technische Eisen.
23 Lamort Fer, 1913-24, 225.
24 Comstock, *Met. Chem. Eng.*, 1914, 577; St.u.E., 1915, 296.

25 Benedicks, "Inclusions in Iron and Steel."
26 Mineralogy. Miers.
27 Schneiderhöhn-Ramdohr. Lehrbuch der Erzmikroskopie, 2 Bd.
28 F. Wenes Mitt. R.W.I. f. Eisenforschung 4, 1922, pp. 81-86.

Fig. 27.—A same specimen etched with 2% HNO_3 × 2·5.

Fig. 29.—Microphotograph of a burnt cast-iron unetched specimen showing angular crystal of titanium nitride under ∥ nicols × 270.

Fig. 30.—The same specimen as in Fig. 29, photographed under + nicols × 270. In this case the crystal is very bright owing to double refraction.

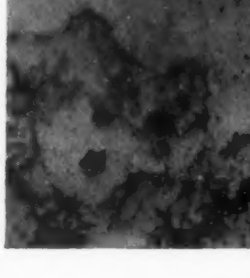


Fig. 31.—Showing an unetched piece of cast iron burnt at a high temperature under || nicols × 270.

Fig. 32.—The same specimen under + nicols × 270. This produces a beautiful reflection effect.

Fig. 33.—Grey cast iron containing thick graphite flakes as seen under || nicols × 270.

Fig. 34.—The same specimen as in Fig. 33 as seen under + nicols × 270.

It will be noted in this structure that differentiation for the various orientation of crysta grains is well defined under + nicols.

present research confirms this view, and at the same time indicates direction of usefulness in metallography, since the effect of graphite on the physical properties is obviously dependent on its quantity and the size and shape of its crystals.

The examination of iron containing graphite, under polarised light, gives a clear idea about its condition. Under the ordinary microscope graphite flakes may give a false impression, for instance, in burnt grey iron where graphite is regarded as oxide inclusions.[29] In reality graphite can seldom be mistaken as an oxide when seen under polarised light.

The optical character of graphite can be easily examined in unetched specimens and there is no danger of confusing its particles with any other structure. Fig. 33 is a piece of grey cast iron containing thick flakes of graphite. The photograph is taken under parallel nicols. It will be observed in this structure that there is no differentiation for the various orientation of crystal grains. But, if the nicols are crossed and the stage rotated, the crystals are well defined, becoming alternately dark and bright. This is clearly shown in Fig. 34, and under cross nicols the natural light yellowish grey colour can be well demonstrated, the gleam of grains being four times extinguished in a complete rotation of the stage.

Temper-carbon.—The reference to graphite as flakes is also true of all other varieties of carbon present in iron in the crystalline form. In temper-carbon, although the double refraction effect may not be so marked as the flakes of carbon in grey iron, yet the fine crystalline structure of this form of graphite is brightened on some crystal faces under polarised light, and can be seen better by this method. Further, the structure can be easily distinguished from slag inclusions, which may acquire the same colour and form as big aggregations as temper-carbon crystals.[30] A comparison of Figs. 35 and 36, showing the microphotographs of an unetched piece of malleable cast iron under parallel and cross nicols respectively, demonstrates how conveniently temper-carbon aggregation can be identified by the employment of polarised light.

Sometimes in temper-carbon the crystal grains are radially arranged, as described by Pinsl. This happens when tempering is extended over a long period,[31] at a somewhat higher temperature. The adjustment of crystals in a radial form, in round balls of temper-carbon, exhibits a very interesting effect under polarised light. Under parallel nicols, as in Fig. 37, the arrangement is not so distinct as when observed under cross nicols, as shown in illustrations A and B, Fig. 38. The structure shows how the crystal faces taper towards the centre, making a perfect arrangement. This structure has got different physical properties.

Iron Alloys.

The investigation of different alloys of iron has received special attention in this work, although only a few of them have given profitable results. Specimens containing various percentages of Cr, Mn, Mo, Ti, and W in pure iron were examined under polarised light, out of which the alloys of Cr, Mn, and W proved to be quite inert under cross nicols.

In the case of ferro-titanium, the inferences drawn from the experiments are not very well confirmed, as with scanty material at hand the research was insufficient. However, the few slides prepared for the purpose show that with more than 20% titanium a clear double refraction is observed under polarised light.

Ferro-tungsten alloys were fully investigated under polarised light, and excellent results were observed. The examination of these alloys reveals that as the percentage of tungsten increases a new phase enriches the structure and at 68% W nearly the whole of the surface is covered

29 Jefferies and Archer, "The Science of Metals," 1924.

30 Schüz-Stotz, Der Temper Guss.

31 H. Pinsl, Die Gies, S rei 12, 1925; No. 34, pp. 651-55.

Fig. 35.—Microphotograph of an unetched piece of malleable cast-iron under || nicols × 270.

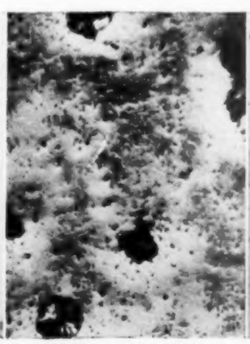
Fig. 36.—The same specimen as in Fig. 35 but under + nicols × 270.

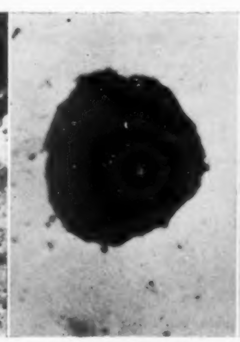
Fig. 37.—Radial temper-carbon under || nicols × 270.

Fig. 38A.—The same specimen under + nicols × 270.

Fig. 38B.—The same specimen + under nicols × 90.

The structure seen under + nicols shows how the crystal faces taper towards the centre.





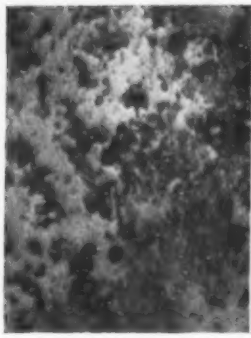


Fig. 39.—Specimen of iron-tungsten alloy containing 78 per cent. W, under ‖ nicols × 270.

Fig. 40.—The same specimen under + nicols × 270. Practically the structure is brightened due to double refraction.

Fig. 41.—A ferro-molybdane alloy specimen, containing 31·5% molybdane under ‖ nicols × 270.

Fig. 42.—The same specimen under + nicols. Note that the dentritic structure is whitish.

with this phase, the structure of which, when examined under polarised light with cross nicols, exhibits a strong double refraction.

The X-ray investigation confirms the presence of this phase, and according to the equilibrium diagram proposed through the investigations this compound exists at 68·5% W, and its composition corresponds to. Fe_3W_2. The crystal structure of this compound is found to be of the hexagonal system.[32] The investigation in polarised light agrees with these results, and proves that this compound really belongs to some anisotropic variety. In Fig. 39 is represented a microphotograph of a piece of iron-tungsten-alloy containing 78% W. The phase is distributed nearly throughout the whole of the ground mass of pure tungsten. The structure is reddish brown in colour, under parallel nicols, but under cross nicols, as in Fig. 40, nearly the whole of it is brightened, due to double refraction. Some points are extraordinarily sharp, seen white in the black-and-white reproduction.

A similar compound formation is observed to be present in ferro-molybdane, having the composition Fe_3Mo_2. The recent investigation cf Arnfelt[33] shows that there is an intermediate phase present in this alloy which belongs to trigonal system. The present investigation confirms this view. Fig. 41 shows this structure in a 31·5% molybdane alloy under parallel nicols. The specimen is also photographed under cross nicols, where the dentritic structure of this compound is whitish, as in Fig. 42.

From the above results, it is hoped that this new scientific method will provide additional facilities for the investigation of these alloys with a view to obtaining complete information for their equilibrium diagrams.

32 Landgraf o Unveröffentlichte Arbeiten, München, *Techn. Hochsch;* Leon Guillet, *Metallographie*, p. 397, Paris.

33 "On the Constitution of Iron-Tungsten and Iron-Molybdane-Alloys," Iron and Steel Institute, London.

The Patternmaker's Foundry Sense.

PROBABLY no single factor has a greater influence on the economic production of castings than the patterns used. Unless the pattern produces an accurate impression without any disturbance of the sand, extra cost is involved in preparing a mould to receive the metal and, generally speaking, it is the duty of the patternmaker to limit the expense in the production of moulds to a minimum. In order that this can be effected, a very wide knowledge of the foundry is essential to the patternmaker, and this was emphasised by Mr. F. C. Edwards, in a paper on the above subject which he read before a recent meeting of the Lancashire Branch of the Institute of British Foundrymen. Mr. Edwards based his remarks mainly on a quotation by Mr. Bernard Shaw, who stated that out of every one hundred persons five possessed directional ability, a quality which was essential to the patternmaker. The writer considered that Mr. Edwards had a great deal of courage in assuming before a very large meeting consisting mainly of moulders, that the 5 per cent. possessing directional ability should necessarily be patternmakers, and that patterns should be made fool-proof.

While recognising that patternmaking demands skill of a very high order, together with directional ability, a very high degree of skill and directional ability is also required by the moulder, and while an excellent pattern is of considerable value in economic production, since it provides the moulder with a tool by which his mould is produced, a competent craftsman can work with inferior tools, and in many foundries this must be done. It must be appreciated that the production of a first-class pattern involves considerable cost, and, as economy must be exercised, a second or third rate pattern may quite well effect greater economy in the production of the ultimate casting when all costs are considered.

All patternmakers, unfortunately, do not possess the requisite foundry sense. It is a variable quality, and only a very small percentage possess it in a high degree. The fault is not entirely with the patternmaker, but rather with the system of training. Many patternmakers who have had considerable experience in the making of patterns have little or no experience of the foundry. Some, in fact, have never been inside a foundry. It is difficult, therefore, for such patternmakers to possess a foundry sense to a degree which Mr. Edwards assumes to be a common characteristic of patternmakers. A foundry sense will vary according to the foundry to which the pattern is to be sent, since different moulders have different ideas on how a mould should be made, and apart from the simpler types of patterns the most sensible method is to secure some degree of co-operation between the foundry and the pattern shop in order that the pattern, as a tool, may meet the requirements of that particular foundry.

There was much in Mr. Edwards' address that was of real value, and the many fundamental principles relating to patternmaking were presented in an admirable and witty form, which made the subject more interesting than it would otherwise have been. One advantage the average patternmaker has over the average moulder is the capacity to read drawings. He is required to visualise the finished structure and to determine what work will be necessary in the machine shop, not only in determining which surfaces require machining and for which an allowance must be made, but in determining the most important surfaces and the method of machining them. It should be remembered, however, that a pattern is a tool in the hands of the moulder, and, if it is possible, he should have some choice in its construction so that it will conform to his wishes and enable him to produce sound castings at a low cost.

Steels in Marine Engineering Service

By T. H. BURNHAM, B.Sc.

"Increased pressures and temperatures in steam raising, with its reactions on propelling machinery, and the rapid development of the oil engine, have necessitated the use of a wide range of special metals, both ferrous and non-ferrous, in marine engineering," said Mr. Burnham, when discussing the above subject at a recent meeting of the Institute of Marine Engineers. The primary demand on marine machinery is reliability with accessibility, and complicated and delicate machinery is unsuitable where steam or oil is used. The economic selection of materials is the art of compromise between first cost and durability—of recent years, conjointly with a demand for increased speed, strict economy has been essential. In terms of mild steel or cast iron, alloy steels are relatively more expensive, but first-cost economy may result in attempting to obtain from a material more than it will stand, or to take out of a machine more than it is capable of, so that long-run results may justify the use of the higher grade material. The author confined his discussion to an examination of special steels which have been placed at the disposal of the marine engineer, an abridgment of which is given in this article.

IN boiler furnaces, heat-resisting steel finds a number of applications—for example, on mechanical grates for water-tube boilers. Reference was made to stokers in the Beaver class ships of the C.P.S.S. Co., which were equipped with heat-resisting steel (ERA), and it is reported that after three years of continuous service they showed no signs of deterioration, and that, apart from distortion of one or two castings, which were afterwards corrected by the addition of stiffening ribs, no trouble whatever was experienced. The stoker makers have established the fact that the cost of first equipping the stoker with the heat-resisting steel is cancelled out over a period of say twelve months to two years, by the cost of renewals of cast-iron parts, although these may have given quite a good life for such material.

Slinker-slicing links are components of chain-grate stokers, which require the use of a heat-resisting steel. In oil-fired boiler furnaces low air pressure burner nozzles and air directors may with advantage be made of heat-resisting steel or equivalent, but in other burners where sufficient air is passed for cooling purposes ordinary steels give good service. Another application of heat-resisting steel is for superheater supports replacing cast iron, which was used in the past. Heat-resisting steels are also used for soot-blower tubes in furnace hot spots and for soot-blower nozzles. On the Continent Sicromal 10 (a chromium-aluminium steel) has been employed for this purpose. Calorised tubes have been used up to a gas temperature of 1,800° F. (982° C.) and withdrawable blowers have been developed of which the nozzles are made of molybdenum steel.

In powdered fuel-fired furnaces heat-resisting steels have been used for refractory supports in furnace space linings. Studs and bolts and hollow nuts have been used in quantities. In connection with fuel pulverisation, all high-speed mills are subject to appreciable erosion, and the use of another special steel for such parts may be noted—viz., wear-resisting manganese steel, which is used for hammers and linings of the fan casings and in the pulverisers.

Boiler Drums.

Considerations of space, weight, and efficiency have led to the use of water-tube boilers for marine purposes, but whilst the high superheat and high pressures to which engineers have proceeded on land have been justified by experience, water-tube boilers have, so far, only been adopted in vessels on special service, which makes their use a necessity. Moreover, the use of high-pressure steam has been delayed owing to the alterations in machinery involved.

Boiler drums used to be of riveted construction, but increased temperatures and high pressures led to the use of seamless drums, and lap-welded drums have also been introduced. The production of seamless forged drums is truly a metallurgical feat. An ingot of sufficient weight is trepanned and hollow-forged to work the material circumferentially and longitudinally, the cylinder being closed in at the ends, leaving only a manhole after machining internally and externally. For marine service, where lightness is important, the ends may be machined down. The drums are heat-treated to remove strains. The expense involved is higher than for riveted drums—in fact the cost may be three times as much. Welded drums have not yet obtained the approval of the British registration authorities, but there seems no objection to the welding of seams of steam and water drums if properly done and combined with scientific control of the seams after welding.

The most suitable material for boiler drums is obviously that which will permit minimum wall thickness for the actual working temperature. Ordinary boiler drum steel is 0.22/0.32 carbon steel having a tensile strength of 28 to 35 tons. The yield-point and tensile strength of mild steel can be raised by increasing the carbon content, but ductility falls and the tendency to heterogeneity and segregation is increased. The addition of 1% of silicon gives a higher yield point, and was used, for example, in the *Mauretania*, but some difficulty may arise in rolling this type of steel.

Experience was gained by the Admiralty with D and D 1 qualities, the analysis of which is approximately ·30/0·33% carbon, 1·0/1·2% manganese, $<$ 0·2% silicon. The properties which include a specified proof stress of 16–17 tons, a tensile strength of 37–44 tons, with 17% minimum elongation (on 8 in.) appear to be controlled by the choice and control of finishing temperature (830/860° C.).

More recently, high-tensile steels have been developed by the addition of small percentages of chromium or molybdenum or both to low-carbon steel, with a small addition of copper to improve resistance to corrosion. The advantages include higher yield-point, elongation shock test, the tensile properties are independent of rolling conditions, and no special heat-treatment is necessary.

Suitable Rivet Materials.

To derive full benefit from the use of high-tensile steels in riveted boiler construction, the quality of the rivets must be raised in the same proportion, and suitable rivet materials have been developed which can be driven by ordinary methods. They are made from steel a few tons tensile stress lower than the plate material, as they are found to harden up slightly on driving. The rivets do not

air-harden or crack, and no special precautions are taken beyond attention to the carbon-manganese ratio as in ordinary steel.

Use has been made of 3% nickel steel for boiler drums, but a number of investigators have reported no improvement in creep resistance. In some cases high-tensile steels, based on the additions of chromium and copper, the manufacturers claim that the tensile properties are improved at temperatures above the normal, but experience has not so far proved this, and it is usual to add a small percentage of molybdenum (about 0·5%) for such purposes. The yield-point then falls off less rapidly as the temperature is increased, while the creep strength is considerably improved up to 500/550° C. Above 450° C., however, a tendency to inter-crystalline weakening under time and stress has been recorded which is being thoroughly investigated by various research bodies.

Bolts for Steam Piping.

With the advent of higher steam pressures and degrees of superheat, trouble was experienced with flanged joints in steel piping, due to bolt stretch relieving the gasket pressure. The bolts are stressed, due to the differential thermal expansion of bolts and flanges. Ordinary steel bolts are found to creep above a temperature of 750° F., and nickel-chromium steel bolts become embrittled from repeated heating and cooling. A suitable bolt steel for high temperature steam-piping must not only possess high creep resistance, but also be immune from temper brittleness and deterioration from exposure to steady or alternating temperature.

Temper Brittleness.

The phenomena associated with temper brittleness in some steels—*e.g.*, low nickel-chromium and 2 to 3% manganese steels—are well known and fairly well understood, but embrittlement at the temperature of superheated steam occurs over longer periods and in steels which are free from the ordinary form of temper brittleness, long exposure at 450° C., for example, bringing about brittleness in many varieties of steel. It is well known that molybdenum greatly reduces embrittlement due to prolonged heating, but for long exposures the content is important and is advisably kept over 0·5%.

Marine engineers are largely, if not principally, concerned with safety. They want to know if the materials they employ are adequate to meet the working stresses in their plant, and whilst special bolt steels have been in service for years at elevated temperatures, it would be idle to suggest that metallurgists have fully explored or understand the phenomena that occur under stress at high temperatures. Molybdenum steels, which are proving to possess useful properties in this direction, have in fact brought into prominence the question of intercrystalline fracture—*i.e.*, above 450° C.—with a slow rate of straining they break along the crystal boundaries. This phenomenon, however is thought to occur in all steels to a greater or lesser extent.

Much systematic research is being carried out at the National Physical Laboratory and in the laboratories of the large steel works, not only on the effect of flue gases and superheated steam on alloy steels used in boiler plant, but to elucidate the phenomena of high-temperature failures and increase the reliability of the steels at the disposal of engineers and constructors.

As regards steam-pipes themselves, special steels, such as the 0·5% molybdenum steel, are under consideration where, owing to high temperature, stronger pipes are necessary than would be possible for mild steel without undue thickness. The use of high temperatures in steam raising depends to an important extent on the provision of suitable superheater elements, and from the materials point of view the engineer's chief interest is to know whether those commercially available are reliable at these high temperatures. For marine service a steam temperature of 775° F. has already been attained, and it is considered practicable by some marine superintendents that in the near future a temperature of 1,000° F. will be reached.

Superheater Tubes.

Ordinary mild steel superheater tubes have given good service up to 750° F. (400° C.), and in fact a leading firm of boiler makers use a good killed 0·12% carbon steel up to a temperature of 850° F. (450° C.). On the other hand, some engineers have a sense of insecurity when exposing mild steel for continuous service to a furnace gas temperature which gives a steam temperature of the high figure mentioned, and it is generally agreed that above a steam temperature of about 800° F. the use of alloy steels is not only advisable but necessary.

There is a divergence of opinion between users as to their requirements of superheater tube materials, but among the desirable qualities may be included :—

1. Resistance to oxidation and attack by furnace gases.
2. Resistance to corrosion and attack by superheated steam.
3. High-limiting creep strength.
4. Ease of working, flanging, bending, expanding, etc.
5. Absence of temper brittleness or deterioration from continued operation at high temperature.
6. Coefficient of expansion of the same order as the headers into which the tubes are expanded.

From the above it will be seen that the mildly alloyed steels meet the requirements as regards workability, but have no special claims with regard to resistance to oxidation. The first economic move as temperatures are increased is to add molybdenum from 0·3 to 0·6%, this element doubling or tripling the creep strength of mild steel.

An advantage of non-scaling materials is that a better conduction of heat occurs, and heat stresses are consequently diminished. If high mechanical properties are combined therewith, wall thickness can be reduced and efficient heat transference is facilitated. Steels containing silicon and aluminium are a definite improvement as regards non-scaling properties, but are not readily workable when cold. When hot, they become considerably tougher, and can be bent and expanded at elevated temperatures. Aluminium-coated tubes resist oxidation. Low carbon-silicon-chromium tubes offer better resistance to oxidation than ordinary stainless steel, and the creep strength is higher than that of mild steel. Cold-drawn tubes present difficulties in manufacture, but hot-rolled superheater tubes of this type have been used in this country. Perhaps the best combination may be found in the chromium-silicon-molybdenum type of steel.

For installations involving steam temperatures of the order of 1,000° use has been made of 18/8 type of nickel-chromium tubes. This class of steel possesses not only high resistance to oxidation and corrosion, but also high limiting creep stress. Unfortunately, it has a high coefficient of expansion, and as expanded joints are unsatisfactory, welding has to be resorted to. Moreover, straight 18/8 steels develop intercrystalline corrosion brittleness between the temperatures of 540° and 185° C., so that the addition of small quantities of other elements, such as tungsten or titanium, is made to avoid carbide and ferrite formation at operating temperatures. Their cost is high, probably ten times that of ordinary mild steel tubes, and many investigations have been made to produce tube steels having the required reliability at high temperatures, but at a lower cost.

Steam Valves.

Valve bodies are usually made of ordinary carbon steel castings or forgings, the smaller valves as drop forgings. For use with steam at high temperatures and pressures, a molybdenum steel or a chromium-molybdenum steel (C 3, Cr 1/1·5, Mo 0·8) having enhanced resistance to creep have been employed. Some valve makers do not admit the necessity of an alloy steel valve body as the designs are so strong than the stresses in the wall are small, and it may be said that for the bulk of current needs

ordinary steel is satisfactory and economical, but for high steam temperatures alloy steel eliminates thick and heavy designs.

Most makers use some type of stainless steel for the spindles, and a high nickel-copper-tin alloy for the seats, though some engineers employ a corrosion-resisting steel valve seat also. The non-corroding steels generally used belong to one of the three following classes: (1) High chromium, 12/14% or 18%, the latter being more resistant to electrolytic corrosion; (2) 18/8 chromium-nickel steels; (3) 35/12 nickel-chromium steels.

Recently nitrarded steel has come into service for valve components—*e.g.*, gate-valve seatings, as it is more resistant to corrosion than ordinary steel, and its high superficial hardness, which does not fall off up to 500° C., enables it to resist wear and abrasion.

Air Heaters.

Not much trouble is experienced with heat scaling in boiler air heaters, but it may occur from corrosion, which may arise owing to the high sulphur content of some coals and alkali salt impurities, which volatilise and condense in the upper and cooler parts of the pre-heater. Condensation of moisture occurs on the gas side, when the temperature falls to the dew point, and SO_2 and SO_3 may be dissolved. In tubular air heaters the steam blowing necessary for cleaning sets up corrosion, as it hydrolises the salt deposit and probably also oxidises the sulphur absorbed in soot. Soot troubles may also arise with highly volatile coals. Care is usually taken not to allow the gas temperature to fall below 250° F. by passing or recirculating the air where necessary, but sometimes it occurs in practice, and to resist corrosion copper-molybdenum and nickel-chromium corrosion-resisting steels have been used. In cases where air heaters are inaccessibly situated for inspection and renewals the longer life given by alloy steel merits careful consideration.

Turbine Construction.

The requirements of turbine blading material may be briefly recapitulated as follows: Resistance to corrosion and the attack of superheated steam; resistance to erosion or abrasion, by salts at the H.P. end and by water drops at the wet end; mechanical properties to meet the stresses at high temperature; stability or maintenance of physical properties after long service; resistance to intercrystalline attack under working conditions; easy workability and machining, soldering, castings in, etc.; and capability of being rolled or drawn to section.

The steels employed for turbine blading include 5% nickel, 13% chromium, and 35/12% nickel-chromium steels. Other grades of the nickel-chromium type have been used—*e.g.*, 20/22% nickel, 2/4% chromium and nickel-chromium-titanium-tungsten steels. The latter have been shown to be definitely superior to ordinary stainless steel so far as corrosion is concerned.

For marine purposes impulse blading and nozzle vanes of high nickel-chromium steel (35/12 type) have been widely used. Cold-drawn reaction blading is also now produced, though considerable quantities of stainless iron are used for this type of blading.

Turbine discs are usually forged to shape from sections of ingots or blooms of suitable size, the radial flow of the steel during forging being advantageous to the mechanical properties. Medium carbon steel (up to 0·40% carbon) or 3·0% nickel steel, or 0·50% molybdenum steel, have been used. For discs at high speed and temperature nickel-chromium-molybdenum steel (2·5% nickel, 0·75% chromium, 0·5% molybdenum) has been employed.

Severe temperature strains through the structure may produce distortion of casings, and with the raising of the temperature and pressure of the inlet steam, steel has replaced cast iron for temperatures above 450° F. Ordinary carbon steel (C 0·3, Si 0·5, Mn 0·8) has so far proved adequate up to temperatures of 760° F., but for higher temperatures 0·50% molybdenum steel has been employed. In the heat-treated condition the latter has a high yield-point, is tough, and its creep limit at elevated temperatures is considerably above that of ordinary steel.

Ordinary medium carbon steel (0·2/0·4% carbon) or nickel steel (3·5% nickel) or 3·5% nickel-chromium or nickel-chromium-molybdenum steel is used for high-tensile shafts. The steel is usually acid open-hearth, and considerable care is required to minimise segregation of ingots and avoid residual stresses from thermal and mechanical treatment of the forgings.

Gearing.

The requirements of gear steel are soundness, homogeneity, ease of machining, freedom from distortion in hardening, high ductility, shock, and fatigue resistance. Ductility prevents high concentration of stress, and is more desirable than high tensile strength, and high impact value militates against the formation and propagation of cracks. Fatigue failures are usually easily diagnosed. It must be remembered that they are usually initiated by a notch effect or other cause of stress concentration. Wear resistance is not directly connected with hardness—dissimilarity of mating metals appears more important, as it is associated with lower sliding friction. The steels more generally used are medium carbon, 3% nickel or nickel-chromium steel; case-hardening steels; and oil or air-hardening nickel-chromium steels.

At one time the opinion was held that trouble with double-reduction gearing might be due to the treatment which the steel received in the process of manufacture. It was pointed out, however, that the percentage of failures was no more in double than in single reduction gearing, and therefore not a question of design. Cracks were produced by oil-quenching in certain nickel steel samples, but not in others, and whilst it is admittedly possible to produce internal stresses in forgings during heat-treatment, there is little or no likelihood of cracks with modern technique. The consensus of opinion was against the suggestion. On the other hand, the deformation of soft steel relieves the teeth from repetition of a dangerous pressure on the root, and it is considered good practice to have one set of teeth (the wheel) soft enough to embed themselves on the other set.

Pumps and Pumping.

Modern marine practice is to adopt horizontal or vertical centrifugal pumps; but whether for impellers and shafts or rods and rams in reciprocating pumps, corrosion-resisting steels have given satisfactory service. The principal types are:—

1. 12/14% chromium, which is hardenable, excellent physical properties being developed on heat-treatment. It is also used for shaft sleeves (M.S. over 38 tons, E 1·20%).
2. 18/2% chromium-nickel, which resists salt water in contact with yellow bearing metals. It is also used for valve spindles.
3. 18/8% chromium-nickel with or without the addition of special metal, such as molybdenum. Excellent castiugs are made of this type of steel.

Corrosion-resisting steels have, of course, to compete with manganese bronze, Monel metal, and other non-ferrous mixtures in the manufacture of pump components. From communications received from makers and users of pumps and other plant dealing with hot sea water, experience with stainless steels has not always been satisfactory, although it must be stated that the austenitic types are now freer from the defects experienced in the earlier days of their manufacture, such as local pitting and electrolytic action in the presence of non-ferrous metals. Whilst it is recommended that tests should always be made when electrolytic corrosion is likely to intervene—*i.e.*, where composite machinery involves the use of non-ferrous alloys—it may be definitely stated that austenitic steels with high nickel (35/12 type) give extremely good resistance to boiling sea water—of the order of one-twentieth the loss of 12% chromium steel.

The Effect of Low Temperatures on Tensile Properties of Metals

Brief reference to a report of an investigation with forty-one specimens of metals comprising pure iron, carbon steels, alloy steels, copper and nickel and some non-ferrous alloys is given in this article.

THE effect of low tenperatures on the mechanical properties of metals, and especially iron and steel, first received active attention many years ago. The earliest investigations were stimulated by the practical importance of this effect, which, it was known, or suspected, was to embrittle iron and steel. Down to about the year 1900 it is believed that no systematic researches had been made on the mechanical properties of iron and steel below about — 100° C. At that time Sir Robert Hadfield undertook an investigation into the mechanical and other physical properties of a series of irons, ordinary and alloy steels, at the temperature of liquid air (— 182° C.). The tests on the materials used in tbis research were carried out at the Royal Institution in collaboration with the late Sir James Dewar. The results were partly described in a joint paper by Dewar and Hadfield[1], and the complete account in a special monograph by Hadfield[2]. Further progress made in 1920 by which liquid hydrogen (— 252·8° C.) could be produced in sufficient quantities for experimental work, suggested to Sir Robert Hadfield that the opportunity might be taken to settle a metallurgical question of interest. This concerned the existence or otherwise of critical points in the higher percentage alloys of iron and manganese at temperatures even lower than that of liquid air. A further research was therefore carried out in collaboration with the late Professor Kamerlingh Onnes.[3] The changes already observed in the tensile properties of iron and its alloys at — 182° C. have been further studied at the temperature of liquid hydrogen (— 252·8° C.), with the object of determining whether a regular progression occurs in these changes or whether, on the other hand, any critical change or behaviour happens, introducing new features into the tensile properties. The results of this investigation, carried out on 41 specimens of metals comprising (*a*) pure iron (99·85%), (*b*) four carbon steels, (*c*) 30 alloy steels, (*d*) copper and nickel, and (*e*) four non-ferrous alloys, are given by Professor W. J. De Haas and Sir Robert Hadfield in a report recently published.[4]

It is shown that iron, ordinary steels, and most of the alloys of iron which at — 182° C. retained a light degree of toughness, are devoid of ductility at — 252·8° C., though those containing a comparatively high percentage of nickel still retain remarkable ductility. The metal nickel is found to be really stronger and tougher at — 252·8° C. than it is at ordinary room temperature. The mechanical properties of nickel, copper, and aluminium improve with the lowering of temperature down to — 252·8° C. At this temperature copper possesses a tenacity of 29·70 tons per sq. in., with an elongation of no less than 60%.

The general effect of low temperatures in increasing the tenacity of iron and ferrous alloys, and also of other metals, appears to have reached a limit between the temperatures of — 182° C. and — 252·8° C. At the latter temperature iron maintains its tenacity of 52 tons per sq. in., the same figure as that obtained at — 182° C. The effects of a temperature of – 252·8° C. on the mechanical properties are, in general, only temporary, the various materials entirely recovering their normal condition at ordinary temperatures. An alloy containing 0·70% carbon, 0·82% manganese, and 31·40% nickel is an exception, this being a representative of those alloys containing a comparatively high percentage of nickel. These special alloys, with a sufficient content of carbon, manganese, or other element, have long been known to be of an irreversible character.

The rendering brittle at – 252·8° C. of properly toughened—that is, water-quenched manganese steel—appears to be entirely unaccompanied by changes in its metallographic or non-magnetic character. Its behaviour is in marked contrast with that of other austenitic ferrous alloys containing nickel. Of this latter type the representative materials tested either do not suffer any loss in ductility, or if they do are not rendered so brittle as manganese steel. Further, some of them undergo a transformation of structure from austenitic to martensitic—for example, an iron-nickel alloy containing 0·70% carbon and 31·40% nickel.

The authors feel that the further experimental information now obtained has shown the desirability of the extension of the previous researches at liquid air temperatures to the much more severe conditions existing at the lower temperatures of liquid hydrogen; but the explanation for the curious and striking effects of low temperatures on metals yet remains to be sought. They suggest that the increase in tenacity which is, in general, operative, may perhaps be visualised in an empirical way by an increase in cohesion brought about by the closer approach of the atoms to each other, due to thermal contraction. This, however, is not entirely satisfactory. There are materials where at this very low temperature of liquid hydrogen, the tenacity is actually reduced, and this cannot altogether be explained by the extreme brittleness induced by the temperature.

Whatever influence closer packing of the atoms may have had on the tenacity, it does not seem to assist in explaining why iron and many of its alloys become quite brittle, nor the actual improvement in the ductility of nickel, copper, and aluminium, and many of their alloys. Such explanations as have been afforded to explain the ductility, or otherwise, of metals and other crystalline substances have rested on the form of the atomic arrangement rather than on the spacing of the atoms or unit dimensions of the lattice. In this respect there is a distinct difference between iron, which has the body-centred form of cubic structure, and nickel, copper, or aluminium, which have a face-centred cubic form of structure. This fact, however, does not prevent iron having excellent ductility at ordinary temperatures. For atomic structure to be at the root of the question, it is necessary, therefore, to suppose that closer approach of the atoms can, on the one hand, in some way destroy ductility, and, on the other, improve it. The matter is, too, further complicated by the fact that manganese steel, which has the same face-centred cubic structure as all those other metals and alloys which still retain considerable ductility in liquid hydrogen or even improve, is rendered brittle.

The investigation has shown that carbon, when added to iron in a sufficiently small amount—about 0·1 to 0·3 per cent.—actually helps to prevent it becoming brittle. Although it is not effective in this way in liquid hydrogen, it nevertheless improves the ratio by which the tenacity is increased. With a higher carbon addition the low temperature properties of the pure iron are deteriorated. This peculiar effect of carbon the authors find most puzzling and suggest that, until a more intimate knowledge of the change brought about in the internal structure of metals by low temperatures is acquired, a complete explanation of this and other features mentioned can hardly be expected.

1 Proc. Roy. Soc. Vol. 74, p. 326 (1904).
2 J. Iron Steel Inst., No. 1, p. 147 (1905).
3 Proc. Roy. Soc. A. Vol. 99, p. 174 (1921).
4 Proc. Roy. Soc. A. Vol. 232, pp. 297-332 (1933).

Refractory Materials for Blast-Furnaces

By Alfred B. Searle, *Consultant.*

Many refractory materials fail to give satisfactory service because the conditions under which they are used are not fully understood. In this article some essential factors are discussed with special reference to refractories for blast-furnaces.

EVEN a casual consideration of what occurs in various parts of a blast-furnace will quickly show that conditions vary in different parts of the furnace, and also at different times whilst it is in use. In some parts of a furnace the conditions are much less severe than in others, and consequently it is foolish to use the same kind of bricks throughout. Moreover, the conditions in different zones in a blast-furnace vary so greatly that a brick which is almost ideal for one zone is nearly useless in another.

It is of the utmost importance to remember that properties which are incompatible with each other cannot be possessed by a brick. For instance, great mechanical strength and great resistance to abrasion are mainly due to the presence of sufficient binding material, which unites the refractory particles very firmly to each other. This binding agent must, by its very nature, be much less refractory than the particles which it binds, and consequently a brick rich in binding material must be less resistant to heat—*i.e.*, less refractory—than one which consists wholly of refractory material and is, therefore, much weaker mechanically.

If this fundamental fact is borne in mind, it will save much disappointment in the selection of refractory materials for blast-furnaces.

Before deciding on any particular kind of refractory material for a blast-furnace, the master or manager should divide the furnace into a series of zones, the width (or depth) of each zone depending on the size and pattern of the furnace. He should then take each zone in turn, consider carefully what occurs in that part of the furnace and should write down the properties which the bricks in that zone should possess. He should do this separately for each zone. The next step is to attach some indication of the relative importance of each property. The easiest way is to assign marks. Thus, if a property is essential it receives a maximum ot 10 marks ; if a property is ot minor importance it is awarded only 1 mark. Intermediate values receive 2–9 marks, according to their importance. By this means it is fairly easy to decide the kind of brick or block to use in any zone.

The Top Zone.

In the upper part of some blast-furnaces the bricks wear away much more rapidly than is desirable. This is not because they lack refractoriness *per se*, for the temperature in that zone is so low that an iron lining could be used. The wear and tear are due to :—

(*a*) The abrasion of the lining due to the impact of the pieces charged into the furnace. This is the most serious cause of damage, and on that account high marks should be awarded to bricks having this property to an ample extent. Probably no brick would justify an award of 10 marks for this property, but 8 or even 9 are appropriate for some bricks. For resistance to abrasion and impact alone bricks are not necessarily the best material ; iron plates (as suggested) have a greater resistance than any kind of refractory brick.

Incidentally, the abrasion would be much reduced if all the materials charged into the furnace were reduced to pieces 4 in. or less in diameter before being charged. The cost of breaking and roughly screening them would be less than the cost of repairing this part of the furnace.

(*b*) Carbon dioxide and other reactive substances in the furnace gases attack the refractory materials in the upper zones. The more porous the bricks or blocks the greater is the damage done by the gases. Hence, high marks should be awarded to bricks which are low in porosity and permeability.

The extent to which furnace gases, alkalis, and molten slag will attack the lining depends very largely on the surface exposed to their action. If a perfectly impervious brick could be used, this surface would be exactly equal to that of the face of the brick—*i.e.* $9 \times 2{\cdot}5 = 22{\cdot}5$ sq. in. Each open pore of 0·04 in. diameter, length, and depth adds 0·008 sq. in. to the surface, so that even a few pores of moderate size increase the surface by an appreciable extent, and a thousand pores may increase the surface by 10%. Actually, the pores tend to act as channels or guides, and their total effect in increasing the surface is therefore very large. In this connection it should be realised that only the open pores permit the entrance of corrosive agents. The sealed pores are, in the first instance, harmless, but if their walls are destroyed by corrosion the pores are as harmful as open ones.

In comparing bricks by different manufacturers for resistance to corrosion, neither the porosity nor the permeability are wholly reliable guides. A permeability test will show the volume of gas or inert liquid which can be absorbed, but it is the *area* exposed to the corrosive action, and not the volume, which is the important factor, and this area cannot be determined.

The determination of the porosity is equally futile, because it only shows the volume and not the surface area. The porosity determination suffers from another objection, especially as regards slag, because this test shows the total volume of the pores (except sealed pores), many of which are too small for the slag to penetrate.

A further objection to conclusions based on permeability or porosity when determined with inert liquids or gases, is that slag which has once penetrated a brick corrodes the walls of the pores and so makes room for a much larger volume of slag than the volume of the inert liquid used in testing.

(*c*) Volatile metals, such as zinc, lead, etc., tend to become oxidised in the upper zones, and then form fluxes which rapidly corrode porous bricks, but exert a much feebler action on dense bricks. Here again high marks should be awarded to dense bricks for this zone.

The temperature in the top zone of a blast-furnace is not high enough to require much consideration to be given to the refractoriness of the bricks, and 2 or 3 marks would be ample for refractoriness in this zone. In other words, if the bricks used are refractory—*i.e.*, have a refractoriness equal to or greater than Seger Cone 18, or 1,500° C.—that should be sufficient. Not only will no advantage be gained by using bricks with a refractoriness equal to Seger Cone 34 (1,750° C.), but harm would be done, as such bricks would wear away too rapidly through the abrasion and impact of the materials charged into the furnace.

It is often said that the mechanical strength of the bricks in the top zone and in the upper part of the second zone is important. It is not satisfactory to associate " strength " too closely with the crushing strength of the

bricks. The kind of strength required is more nearly related to hardness, and is best tested by means of a Brinell ball or by grinding weighed test-pieces for a prearranged length of time and noting the loss in weight. If a crushing test is to be used, it should be made at a temperature near to that at which the bricks will be used. A "cold" crushing test is of little value and is sometimes misleading.

From the foregoing it will be seen that the best bricks for the top zone are fireclay bricks,[1] which are sufficiently dense and fine in texture to be highly resistant to wear and corrosion. Their refractoriness may be quite low.

Many years ago, in several blast-furnaces, the top zones were built of Staffordshire engineering bricks, with excellent results, and it is difficult to understand why these bricks have not been more generally used.

To resist the sudden changes in temperature when a fresh charge is admitted, the bricks should be porous; if too dense they will spall and crack. This requirement is incompatible with the other essentials for this zone, and is best met by building the furnace sufficiently high to reduce the change in temperature to within limits which the bricks can withstand.

Second Zone or Stack.

The second zone is at a higher temperature than the top one, and the two constitute the *stack* of the furnace.

The abrasive action of the charge is very great in this zone, as is the chemical action of the gases and fluxes. A rather higher refractoriness is needed in the second zone, but so far as refractoriness alone is concerned, few firebricks of good repute could fail to meet all requirements. The failure of bricks in the second zone is not due to lack of refractoriness, but to an open or porous structure which cannot withstand the abrasive and corrosive actions of the charge.

Bricks for lining the second zone may be of the same nature as those for the top zone, though a rather greater refractoriness is desirable. Fireclay bricks containing 26–30% of alumina[2] are usually of ample refractoriness, and if thoroughly well burned they are hard enough and dense enough to resist the abrasion and corrosion of the charge. In the upper part of this zone the bricks may crack or spall because of the sudden cooling caused by the descent of a fresh charge. If the furnace is sufficiently high and is properly managed, this should create no serious difficulty. In any case the use of porous bricks to prevent it is not satisfactory.

One cause of corrosion and disintegration of bricks in the stack is the absorption of alkali chlorides which are volatilised from the charge. If the temperature is sufficiently high, these absorbed salts combine with some of the free silica in the brick to form a molten flux which greatly weakens the brick as a whole. There is no certain remedy; all that can be done is to use dense bricks which have a low power of absorption.

In the stack of a blast-furnace, it is essential to lay the bricks with the thinnest possible joints and with the faces perfectly even. Otherwise the descending charge will corrode the joints and abrade the projecting faces of the bricks. Thin joints can only be made when the bricks are accurate in shape and size, and for this reason machine-made bricks are preferable to hand-made ones.

As it is also essential for the bricks or blocks to be uniformly burned throughout—which is impossible with large, thick blocks—the practice during the past few years has been to use blocks $13\frac{1}{2}$ in. × 6 in. × 3 in. with alternating course 9 in. × 6 in. × 3 in. instead of the larger blocks formerly in use.

Sufficient accuracy in size is obtained if departures from the specified dimensions do not exceed $1\frac{1}{2}$% on blocks or 2% on bricks.

The Hearth, Bosh, and Well.

The hearth and bosh or well are the hottest parts of a blast-furnace, and therefore require to be lined with refractory bricks. At the same time, the bricks must be sufficiently hard and dense to prevent undue penetration by the slag and metal. The use of machine-made blocks, $13\frac{1}{2}$ in. × 6 in. × 3 in., and 9 in. × 6 in. × 3 in., is now preferred to the larger hand-made logs formerly used, as the machine-made blocks are more accurate in shape and size, and can be laid with much thinner joints.

Blocks for the hearth and well should be of medium texture, burned hard, so as to be of low porosity.

There is still much difference of opinion as to whether fireclay, highly aluminous, or silica bricks should be used for the hearth, bosh, and well. The intensity of the reactions which occur in the lower part of the furnace suggests that highly aluminous bricks would be best, and American and Continental practice is largely based on this consideration, bricks containing 40% or more alumina being used. It is essential to remember, however, that a mixture of fireclay and alumina containing free alumina may be of little use in a blast-furnace. The only value of the alumina is when it is combined with the silica in the form of mullite or some similar compound. A mixture of free silica and free alumina in a hearth brick is of little value.

British ironmasters have found that the addition of alumina to a fireclay is seldom necessary, and that fireclay bricks which contain 35–37% of alumina suit all the requirements for hearths, boshes, and wells.

It is also unnecessary to stipulate for a refractoriness exceeding Seger Cone 32 (1,710° C.).

Some ironmasters prefer highly siliceous bricks—*i.e.*, silica bricks or those made of a mixture of fireclay and silica, and containing about 70% of silica. Such bricks are particularly used when working an acid pig. For foundry pig and basic iron, fireclay bricks are preferable.

It is clearly desirable that the proportion of lime, magnesia, potash, soda, and iron oxide in the bricks used in the lower part of a blast-furnace should be as small as possible, but under ordinary circumstances, and using bricks made by a reputable firm, no figures need be specified. There is a widespread idea that the iron (as ferric oxide) should not exceed 2·5%, but this is a wholly arbitrary figure, and many blast-furnace "logs" made in South Staffordshire and containing 5% of ferric oxide have given complete satisfaction. It is not the total amount of iron compounds present, but the size of the particles which really matters, and a few large pieces (even if their total weight is small) can do more harm than twice the weight of finely ground material! It is therefore unwise to specify any maximum permissible figure for the iron compounds present.

The bricks or blocks used in the hearth and bosh should be refractory, and dense enough not to be unduly corroded by slag. Hence, they should be of moderately fine texture, and of low porosity and permeability.

The bricks in the well should be refractory and moderately dense. They should have similar properties to those used in the hearth, but most of them need not be quite so resistant to corrosion, as slag only enters the upper part of the well.

The Present Trend.

The present tendency in blast-furnace practice is (*a*) to use smaller logs than before and of standard sizes; (*b*) to require them to have been fully burned throughout at (*c*) a sufficiently high temperature to ensure the maximum practicable density and a minimum of shrinkage when reheated at 1,400° C. for 2 hours.

(*Continued on page* 88.)

[1] The term *aluminous bricks*, when fireclay bricks are intended, is liable to serious confusion. The term "aluminous" is understood in the trade to mean bricks made chiefly of alumina or of a mixture containing a large proportion of free alumina. To distinguish fireclay bricks from silica bricks by terming the former "aluminous bricks" is undesirable. This note is needed because of the confusion created in some recent academic papers on firebricks.

[2] If fireclay bricks or blocks containing 35–38% of alumina can be obtained for nearly the same price they are to be preferred, because they will usually be more durable, but this is not always the case. The chief advantage claimed for the more aluminous brick is its reputedly greater resistance to alkalis. It is, however, more porous than a less aluminous brick, and may, for this reason, be more seriously attacked.

High-Chromium Iron Alloys for Castings

Some practical notes on alloys for high-chromium iron castings are given. Although other elements are added in small percentages to impart desirable qualities, the essential characteristics of the chrome-iron castings are not materially changed by these additions.

MUCH information available regarding chromium-iron alloys has particular reference to forged and rolled materials, usually with low carbons, and does not necessarily apply to castings. In castings, grain size is usually in direct relation to the rate of cooling, so that the cross-section has much to do with the grain size. Quick cooling produces a smaller grain. Obviously, there will be considerable variation in the same casting, thin sections perhaps having a fine grain while heavy sections will have a large, coarse grain. Depending upon the carbon, it is sometimes possible to refine the grain by heat-treatment, but generally the grain in the as-cast condition cannot be changed.

The subject is discussed by W. F. Furman,[1] who states that in general castings containing over 20% chromium require no heat-treatment for maximum corrosion resistance. The usual normalising treatment to relieve casting strains is required. With carbon under 1.0%, no other heat-treatment has much effect. Castings containing, say, from 20 to 35% chromium, with carbon over 1·0%, are extremely hard in the as-cast condition. With carbons around 2.75% they will show as high as 550 Brinell. It is possible to lower this Brinell hardness by proper heat-treatment, so that simple machining operations can be performed and the original hardness restored by further heat-treatment.

A characteristic which high chromium-iron castings have in common with rolled products of the same composition is the tendency to become brittle if passed slowly through a temperature range between 800° and 1,000° F. A casting containing about 30% chromium, 0·5% carbon, heated to 1,200° F. and then cooled slowly, would become brittle. This brittleness disappears when the casting is again brought up to the temperature. Such castings have to be handled with care if they have been subject to this embrittling range, but only when cold.

Castings containing 16 to 18% chromium, with carbon contents not exceeding 0·35%, were first used commercially because of their resistance to nitric acid and their very satisfactory physical properties. Castings of this type were used in most of the ammonia oxidation plants built a few years ago, for pipe fittings, valves, digesters, etc. This alloy has a tensile strength of about 50 tons per sq. in., with good ductility, and is readily machined. Certain difficulties developed in making them because of a peculiar tendency towards wild heats, resulting in blown castings; this difficulty has been practically overcome in foundries specialising in this alloy.

It is generally understood that in alloy castings corrosion resistance decreases as the carbon content increases. Thus, for maximum corrosion resistance, low carbon content is necessary. Only the carbon not in solution, however, is detrimental to corrosion resistance, because a given amount of chromium is required to satisfy a definite quantity of carbon through the formation of chromium carbides, any given carbon content will therefore rob the iron-chromium solid solution of some of its corrosion resisting chromium. Increase the chromium with carbon constant, will leave more chromium available for enriching the iron-chromium solid solution, thus increasing corrosion resistance. A 27 to 30% chromium-iron with, say, 0·2% carbon, will therefore be much more resistant to corroding media than a 12 to 14% chromium-iron with similar carbon contents. Thus, higher carbons can be carried in the 27–30 range of chromium-iron alloys, which is a distinct advantage in producing castings because the higher carbon gives greater fluidity, which enables the metal to flow more freely, and it produces a smaller, denser grain. Melting and moulding costs are reduced, and from the standpoint of corrosion resistance, a small grain is in itself an advantage.

Castings containing about 28% chromium and under 0·1% carbon are being produced, where maximum resistance is essential, but Mr. Furman states that it is not really necessary to carry the carbon so low with a chromium content approaching 30%. Corrosion resistance is practically as good against most media with a carbon content as high as 0·25%, and as a rule a sounder grade of castings result. It is suggested that a safe rule is to keep the carbon to a maximum of 1/1000th of the chromium content, and even this is too severe a restriction for many applications. Increasing the carbon content has almost no effect on the oxidation resistance. A 27 to 30% chromium-iron casting, for instance, will resist oxidation in an oxidising atmosphere very satisfactorily at temperatures up to about 1,900° F., and satisfactory for most purposes up to 2,100° F. This remains true even if the carbon is raised as high as 3·0%, although castings with the higher carbon contents would be more liable to crack at these high temperatures.

Castings with about 0·5% carbon comprise the bulk of the tonnage produced. Such castings have a very satisfactory resistance to most corroding media, and are excellent for high temperature applications where the greater strength which the nickel-chrome alloys have is not a requisite. Because of the higher carbon, they have a denser grain than the low carbon castings, and slightly greater physical strength, though also slightly less ductility. They machine readily, being comparable to medium carbon steels in this respect.

There are times when other alloying elements, added to the straight chrome iron alloys, is desirable for castings. It is well known that nickel in appreciable quantities adds considerably to strength at high temperatures, but nickel is a disadvantage in castings subjected to sulphur gases, so that it is frequently necessary to decide whether to sacrifice strength for corrosion resistance or vice versa. The solution is sometimes found by adding 2 or 3% nickel to a 28–30% chromium-iron alloy. Such an addition tends to produce a finer, denser grain, adds some ductility and increase of strength at high temperatures to some extent.

High-chromium iron castings usually contain about 0·5% manganese, the amount depending upon the melting conditions. Some casts have been made in which a 24% chromium alloy contained as much as 10–12% manganese. Such castings have advantages. The manganese adds strength at high temperatures, without being susceptible to sulphur attack. It was found that grain growth was greater than in the castings of straight chrome-irons, although oxidation and corrosion resistance was about the same.

Molybdenum added to the 27–30% chrome-iron castings, in quantities up to about 4·0%, materially increases resistance to sulphuric and sulphurous acids. An alloy of about 28% chromium, with 1·5 to 3·0% molybdenum and low carbon, is stated to have excellent service in sulphite pulp mills, and has the advantage of not being susceptible to intergranular corrosion. The increase of strength from the addition is apparently not effective at temperatures

[1] W. F. Furman, Metals and Alloys, Vol. IV., Nos. 10 and 11, pp. 147-150 and 167-169.

over about. Tungsten additions also tend to increase the physical properties of chrome-iron castings, but here again such additions are not usually effective about 1,600° F. Small percentages of nitrogen (under 1·0%) added in the form of high nitrogen ferro-chromium have a remarkable effect on chrome-iron castings in refining the grain, and in increasing ductility and strength. Tests show that corrosion resistance is slightly increased. There is some tendency for the nitrogen-bearing castings to contain gas pockets, but it seems to be possible to overcome this by taking precautions in melting.

As may be expected, the melting and casting of chrome-iron presents peculiar difficulties. Often a considerable change in foundry technique is required for a slight change in analysis. The higher the carbon, within the ranges discussed, the more fluid the mixture coming from the furnace, so that the close temperature restrictions which apply to the low carbon alloys are not so important. The low carbon heats are very sluggish, and can only be poured successfully into the moulds when fairly hot; but the pouring temperature has a direct influence on grain size, because the higher the pouring temperature the larger the grain size in the casting; it is therefore necessary to pour on the cold side to ensure as small a grain as possible and yet have the heat hot enough to flow. This means a narrow temperature range for pouring. Moulds have to be prepared with great care, and there are many other factors which have a decided effect on the quality of castings produced. It will be understood from this that castings of identical analysis produced in different foundries will vary considerably in their characteristics, because of a difference in foundry methods.

Forthcoming Meetings

INSTITUTION OF MECHANICAL ENGINEERS.

Jan. 26. "The Automatic Combustion Control of Boiler Plants," by L. L. Robinson, M.I.Mech.E., and J. L. Hodgson, B.Sc., M.I.Mech.E.

Feb. 16. "Design of Crane Hooks and other Components of Lifting Gear," by Dr. H. G. Gough, M.B.E., H. L. Cox, and D. G. Sopwith, B.Sc., A.M.I.Mech.E.

GLASGOW BRANCH.

Feb. 1. "High Speed Diesel Engines for Marine Service," by H. R. Ricardo, B.A., F.R.S.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

Jan. 26. "The Possibilities of Applying Improvements Effected in Modern Land Power Plant to Ship Propelling Machinery," by W. T. Bottomley, E. W. Corlett, and Frank Piercy.

Feb. 9. "Auxiliaries of Marine Engine Installations," by P. L. Jones, M.C., M.Inst.C.E.

TEES-SIDE BRANCH.

Feb. 15. "Recent Advances in Electric Welding," by Dr. J. H. Paterson.

ROYAL AERONAUTICAL SOCIETY.

Feb. 1. "Engine Cowlings," by J. D. North, F.R.Ae.S.

Feb. 8. "Engines," by Captain A. G. Forsyth.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

Feb. 13. "Some Influences on the Ship Owner's Choice of a New Cargo Vessel," by R. R. Campbell and B. Ramsey.

INSTITUTE OF METALS.

BIRMINGHAM SECTION.

Feb. 1. Open Discussion on the Metallurgical Inspection of Engineering Materials.

Feb. 13. "Age-Hardening Copper Alloys," by Maurice Cook, Ph.D., M.Sc.

LONDON LOCAL SECTION.

Feb. 8. "Electric Annealing and Heat-Treatment Furnaces," by A. G. Lobley, M.Sc.

NORTH-EAST COAST SECTION.

Feb. 13. "The Flow of Metals in the Extrusion Process," by C. E. Pearson, M.Met.

SCOTTISH SECTION.

Feb. 12. "Fuel," by J. A. C. Edmiston.

SHEFFIELD SECTION.

Feb. 9. "Recovery and Refining of Precious Metals," by H. G. Dale.

SWANSEA SECTION.

Feb. 19. "Cracking and Fracture of Metals with Special Reference to Service Breakages," by Professor F. Bacon, M.A.

INSTITUTE OF BRITISH FOUNDRYMEN.

BIRMINGHAM BRANCH.

Jan. 27. Annual Dinner.

Feb. 9. "Patternmaking," by F. C. Edwards.

EAST MIDLANDS BRANCH.

Jan. 27. "Some Non-Ferrous Foundry Problems," by F. Dunleavy.

LINCOLNSHIRE SECTION.

Jan. 20. "Modern Cupola Practice," by H. H. Shepherd.

Feb. 17. "General Foundry Practice," by J. Sherwood.

LANCASHIRE BRANCH.

Feb. 3. Annual Dinner.

Feb. 17. "The Production of Specially Hard Cast Irons by Alloying and Heat-Treatment," by F. W. Griffiths, M.Sc.

BURNLEY SECTION.

Feb. 13. "Iron Foundry Practice Modernised," by R. H. C. Weeks.

PRESTON SECTION.

Feb. 7. "Refractories and their Application," by J. Masters.

LONDON BRANCH.

Feb. 7. "Porosity in Non-Ferrous Metal Castings," by G. L. Bailey, M.Sc.

MIDDLESBOROUGH BRANCH.

Feb. 9. "Some Notes on Special Steel Production—Historical Manufacture, Properties, Defects," by J. N. Kilby, M.I.Mech.E., F.C.S.

SCOTTISH BRANCH.

Feb. 10. "The Value of Temperature Control in Metallurgica Practice," by Professor Robt. Hay, D.Sc.

FALKIRK SECTION.

Feb. 3. "Metallography of Iron," by N. A. W. Erskine.

EDINBURGH SECTION.

Jan. 27. "Problems in Woodworking Machinery Castings," by B. Ballantine.

SHEFFIELD BRANCH.

Feb. 16. "Alloy Pig Irons," by J. H. D. Bradshaw.

WALES AND MONMOUTH BRANCH.

Feb. 17. "Coke and its use in Modern Foundry Practice," by E. Wautier.

MANCHESTER METALLURGICAL SOCIETY.

Jan. 31. "Alloy Steels," by J. A. Jones, M.Sc.

Feb. 14. "Age Hardening," by Dr. W. Rosenhain, F.R.S.

Refractory Materials for Blast-Furnaces

(*Continued from page 86.*)

The stipulations of very high refractoriness and of a very large percentage of alumina are considered less important than formerly, and whilst the requisite refractoriness must, obviously, be an important property, it is now realised that what is required varies in different parts of the furnace, and may have to be subservient to other and more essential properties.

There is still much to be learned from accurate observations of the behaviour of refractory materials under laboratory conditions simulating those occurring in blast-furnaces. To dignify such observations by the term *research* is, perhaps, to mis-name them, but their importance cannot be minimised. The fact that ironmasters and firebrick manufacturers are now jointly subscribing to enable investigations to be made on refractory materials is a hopeful sign of improvements in the linings of blast-furnaces in the new future being equal to, or even greater than, those made during the last twenty years.

British Machinery for Russia

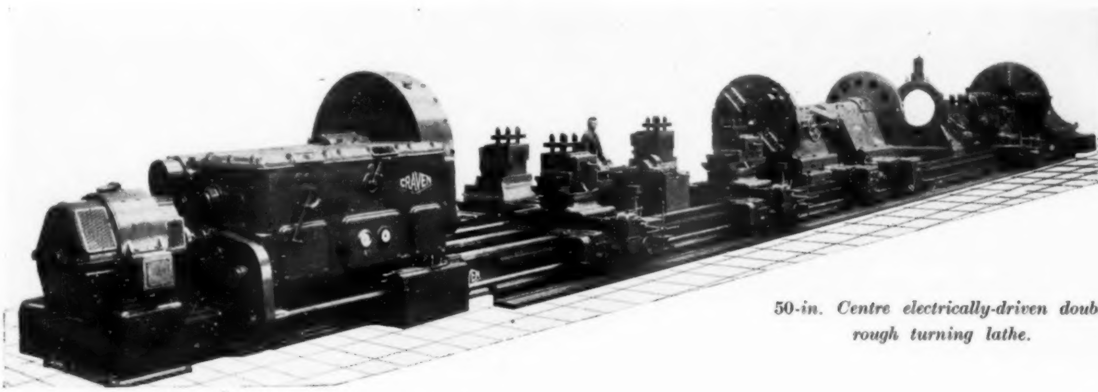
Some British firms continue to supply Russia with plant and equipment, and in this article reference is made to some machine tools designed and built for large works; with a return to normal trading facilities between the two countries it is claimed that more orders for machinery would be placed in this country.

INDUSTRIALISM is progressing in Russia to a remarkable extent and huge areas are being developed that formerly were practically uninhabited. The projects planned indicate vision, enterprise, and energy characteristic of the world's pioneers. Since the revolution the whole attitude of the Russian people has changed. Under the present régime this country has socialised its land, capital, and means of production, and is applying all the energy at its command in attempting to adjust its resources to the needs of its people. Each succeeding year during the last sixteen years has seen a gradually increasing development in plant and production, and this is being supported by centralised scientific, technical, and experimental work, so that close co-operation between theoretical research and practice may be assured.

In a comparatively short time huge projects have been developed and completed, and in the consummation of these projects whole areas have become seething with life and activity in the building of industrial centres, and towns have been created which are constituted on model lines. In this progress and achievement by Russia much has been done by British enterprise; but, in view of the increasing development contemplated in that great country, there are ample opportunities to assist Russia further towards successful achievement. No nation can be prosperous without others sharing in her prosperity; thus, obviously, in helping Russia, Britain participates in her prosperity, and by supplying goods that Russia requires to develop her resources promotes mutual prosperity.

Despite the fact that no trade agreement has yet been arranged between representatives of the two countries, there are many firms of repute that continue to maintain excellent commercial relations with the Soviet Government. The squabbles that have taken place from time to time have had no influence on these firms; they have continued to supply the need for plant and equipment so necessary to the fulfilment of the many projects embraced by the second five-year-plan. Of these mention may be made of Messrs. Craven Brothers, Ltd., of Manchester, who have supplied a very wide range of machine tools, some of which are of an outstanding character, notably a number of electrically-driven double rough turning lathes, one of which is shown in the accompanying illustration. In keeping with the massive character of some of the projects, this machine is somewhat unusual in size and design, and some particulars respecting it will be of interest.

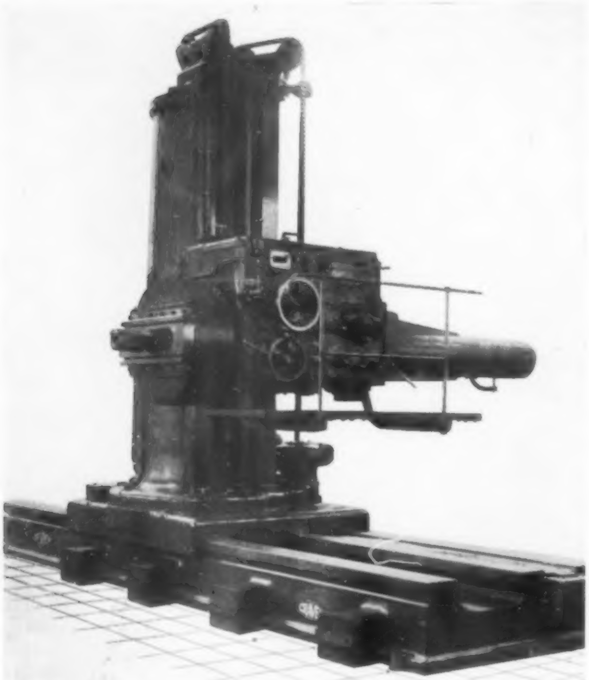
It is appreciated that remarkable progress has been made in the design of machines to facilitate the machining of high-duty materials. The cutting power has been improved to a degree formerly considered impracticable, and this has necessitated machines being built on sturdy lines to withstand heavy and continued service. The range of machine tools designed and built by Craven Brothers for the Soviet Government take full advantage of these modern developments, and they are built in such a manner as to maintain absolute rigidity in operation under the most exacting conditions.



50-in. Centre electrically-driven double rough turning lathe.

As will be noted in the illustration, this rough turning lathe comprises two single lathes on one bed, each having two front and one back saddle, totalling six saddles. The length of the bed is 112 ft., and, used as a single lathe, it will admit between the centres work up to 75 ft. in length, and will swing over the saddles work up to 80 in. in diameter. Operating as a double lathe, it will take work up to 32 ft. 6 in. in length, and will cope with pieces up to 80 tons in weight. The whole machine, exclusive of electrical equipment, weighs 258 tons, and, operating as a single lathe, is driven by a 200 h.p. motor.

Built on massive lines, with the object of ensuring stability and the elimination of vibration when used to remove the maximum amount of metal in the shortest time, this machine has many interesting and valuable features. The main casting forming the bed is of substantial box-type construction. It is designed so that the saddles slide on square-section ways, and additional width is given to provide an ample base for both back and front saddles. The main and intermediate headstocks are constructed on similar substantial lines and all gears are totally enclosed. The spindle is of large-diameter, high-carbon steel, revolving in phosphor-bronze bearings, and ball-thrust bearings take the end thrusts from the spindle. The first and final drive wheels in the headstocks are cut single helical, and all the gears are heat-treated. They are designed to operate at speeds suitable for using high-speed cutting materials, and, to ensure stability, all auxiliary shafts are splined and run in roller bearings. The change gear handles are arranged on the front of each headstock with convenient facilities provided for examining the gears



High-speed electrically driven horizontal boring, drilling, milling and tapping machine.

when the machine is in operation. As will be noticed, a tachometer and ammeter are provided in a convenient position. The face-plates attached to the spindle are of extra heavy section and are fitted with removable heat-treated steel jaws.

The loose headstocks are designed with a very wide base to eliminate vibration, and each is mounted on a sandwich plate, which has a set-over adjustment for parallel or slightly taper turning. Each loose headstock is also fitted with a revolving spindle carrying a four-jaw chuck and an adjustable point centre. This special design of loose headstock gives additional support to the work for extra heavy roughing, and may also be used for rough turning hollow forgings and other work of such a character which could not be held on the ordinary type of centre.

Each saddle is of the single type, and is designed with eight reversible speeds, for both sliding and surfacing, which are provided with interlocks and safety slipping clutches. Each saddle is fitted with self-acting surfacing motion, self-acting sliding motion, and quick motion along the bed. All motions are under easy and convenient control. The feed is driven by an enclosed gear in the headstock through a shaft supported on self-acting bearings of special design. The drive is effected by means of variable speed electric motors giving a speed of 250 to 750 r.p.m., which is transmitted through change gearing in the headstocks.

This machine is provided with interlocking devices on each motion so that no conflicting gears can be engaged. Special attention has also been directed to lubrication, with a view to the smooth operation of the various parts, a cascade oiling system supplying oil to the gear teeth.

Another example of the type of equipment supplied by this firm to the order of the Soviet Government is the high-speed electrically-driven horizontal boring, drilling, milling, and tapping machine, which is also illustrated. This machine is also extremely sturdy in construction and carries a 6-in. diameter spindle. Some idea of the capacity of this machine may be judged from the fact that the centre of the spindle is 8 ft. 6¼ in. above the baseplate, and the horizontal traverse of along the bed is 13 ft. 2 in. The drive is supplied by a 30 h.p. motor running at 750 r.p.m., which is transmitted through change gears to the main spindle to give 16 spindle speeds varying from 1·5 to 150 r.p.m., while there are six spindle feeds ranging from 12 to 80 cuts per min., and six milling feeds, with a range varying from 1·5 to 9·5 per min. The approximate weight of this machine, excluding the workplate and electrical equipment, is 24 tons.

These machines are typically British and built to give long and efficient service. The manufacturers have always made a feature of sturdiness in construction, but these are exceptional in this respect. Despite their massive construction, they possess all the refinements of smaller machine tools of the same type; they present excellent examples of the experience of the machine-tool designer, and illustrate the strides made in the progress of large heavy-duty machines for special purposes.

It is gratifying that some firms continue to supply the Soviet Government with machinery, but the quantity supplied by British firms is relatively small, certainly much smaller than it ought to be, and, in view of the Russian construction programme planned for this year, to which brief reference is made elsewhere in this issue, speedy arrangements should be made between the representatives of each country to facilitate the trade and enable a greater number of British products being utilised in these projects. Many problems are involved in coming to an agreement, but they should not be insuperable, and a satisfactory solution would be a mutual benefit.

Light Weight Diesel Engine Design.

Discussing some phases of the above subject before the third national meeting of the Oil and Gas Division of the A.S.M.E.,* Mr. P. B. Jackson, stressing the value of aluminium, said the outstanding and most generally recognised property of this material is its low specific gravity. It weighs 0·1 lb. per cu. in., as compared to 0·26 for cast iron, 0·28 for steel, and 0·31 for bronze. While these figures are very attractive, the low weight of aluminium alloys is only one of many physical characteristics that must be recognised when using this material in engine construction. The relatively low modulus of elasticity should be given careful consideration, particularly when replacing steel, the moment of inertia must be increased three times. This increases sections approximately 30%, with a resulting saving in weight of some 40%, and a reduction of stress of 56%.

When determining sections of equal rigidity of cast iron the moment of inertia must be increased 50 per cent., which results in sections 10% larger than the cast iron. The actual aluminium castings designed with these increased sections will be approximately 55 lb. lighter than cast iron, and have a stress factor 26% less than the iron castings. It is well for the designer of aluminium parts to become thoroughly familiarised with these relating facts. Stress is laid on this point, because the majority of parts which may be made of aluminium are stressed by bending, and the rigidity of the design is the most essential consideration. Invariably, when parts are sufficiently rigid, the stress is so low as to eliminate any need for anxiety.

Mersey Shipyard to Reopen.

Further promising shipbuilding news has come to hand which involves the reopening of a Mersey shipyard. This concerns Messrs. Cammell Laird and Co., Ltd., who have received orders from the Booth Steamship Company to build two new cargo steamers of about 5,000 tons each. The first, we understand, is to be completed this year, and the next early in the spring of 1935. It is stated that both these vessels will be laid down in the South Yard, which has been idle for about two years. This firm has also received contracts for two vessels from the Trinity Brethren, and it is stated that, with these new boats, twelve vessels will be on the stocks, including two destroyers and two submarines.

* A.S.M.E. Trans. 55, 14, Nov. 30, 1933.

Developments in Soviet Russia

Industrial Planning in Russia is proceeding at an increasing rate and during 1934 provision is made for tremendous capital investments exceeding anything previously contemplated. Some indication of the projects put into operation are given in this article.

IN view of the efforts now being made to effect a trade agreement with Russia, it will be of interest to have authoritative information regarding the remarkable progress being made as a result of the state planning of industry in the Soviet Union which we are able to publish from a speech recently delivered by Mr. Mezhlauk, Vice-Chairman of the State Planning Commission of the U.S.S.R. It will be appreciated that the capital investments involved in this industrial planning, both in regard to completed and contemplated plants, is very considerable, and the sooner an amicable arrangement is made between the two countries to facilitate trade relations the sooner will industries in this country, as well as Russia, benefit.

The Soviet plan for 1934 provides for tremendous capital investments. Although 17,990 million roubles were invested in 1933, the amount estimated for 1934 is 25,111 million roubles. This is the first time the capital investments are to grow by more than 7,000 million roubles in one year; such a sum only recently constituted the complete annual programme for the entire socialist construction. Some indication of the tremendous character of the plants constructed and put into operation during 1933 will show how the capital has been used. It is only possible here to refer to a few of the larger units, but it is of interest to note that 52 coal mines, with an aggregate capacity of 29 million tons, began to operate in 1933 at a cost of 183 million roubles.

Huge plants, such as Zaporozhstal, with four rolling mills, one blast furnace, and seven electric furnaces, aggregating 175 million roubles in value, started operations. There is also the Azovstal metallurgical plant in which 148 million roubles have already been invested, the Zestafoni plant in Transcaucasia, the Ufaleisk nickel plant, the giant Dnieper aluminium plant, and the Chimentsk lead plant, which has been delayed somewhat by failure to put the finishing touches to it, is about to enter operations. A zinc plant in Ordzhonikidze has also begun to operate. Finally, there is the first caterpillar tractor plant in Chelyabinsk costing 253 million roubles; the huge Uralmarsh heavy machinery plant, costing 210 million roubles; the new Lugansk locomotive plant, costing 162 million roubles; the Stalinogorsk nitrogen fertiliser combine, in which 183 million roubles have already been invested; the Gorlovka nitrogen fertiliser plant; the Svir electric station, in which one turbine has begun to work; the Dubrovka and Rion power stations.

The colossal Vakhsh irrigation scheme has been completed at a cost of 71 million roubles. This irrigation system is bringing life to the fertile Vakhsh valley in Tajikistan. There has been opened the Baltic-White Sea Canal, the cost of which, estimated at 104 million roubles, is no indication either of its importance or of the amount of work carried out on it.

Railroads in Operation.

The following railroads have been put into operation:— Novosibirsk to Leninsk, Sverdlovsk to Kurgan, and others. Part of a second track linking up Moscow with the Donetz Basin, and having a length of 560 km., is about to be opened for traffic. A bridge has been built across the Oka River, the pride of the city of Gorki. In a few days a second bridge, over the Volga, is to be opened. Certain sections of railroads have been electrified, including the Kizel-Chusovaya line, 112 km. in length, and the Zestafoni-Stalinisi line, 63 km. long. The enormous Mozheres railway repair shops have been opened near Moscow at a cost of 37 million roubles.

Iron and Steel Industry Grows.

In the iron and steel industry there have been opened seven blast furnaces with an aggregate capacity of 1,835,000 tons of iron a year, this being equal to about half the total pre-war capacity of the Russian iron and steel industry; 28 open hearth furnaces, with an annual capacity of 1,550,000 tons of steel; 12 electric furnaces aggregating 105,000 tons of high grade steel; 12 rolling mills, including three blooming mills, with a capacity of 200,000 tons of sheet iron and three million tons of rolled steel. The example of the Kuznetsk blooming mill, which has already reached its designed capacity, shows that under the conditions operating, this can be achieved in even shorter periods than is the rule in other producing countries. Two pipe rolling mills of 130,000 tons capacity are being put into operation. The coke-chemical industry has increased its capacity by 1.3 million tons.

Construction in 1934.

The plan of capital investments in 1934 provides, in addition to a rapid growth of investments in heavy industry, particularly in certain branches (electrification, chemicals, machine building), an enormous growth of investments in those fields which serve the social and cultural demands of the population, and in the industries producing articles of personal consumption.

This plan provides for an enormous volume of construction. In 1934 several giant enterprises, such as we have not known in any of the previous years, will begin to be built. The Baltic-White Sea Canal is now being converted into a combine, the construction of which will absorb 96 million roubles in the first year, a sum nearly equal to the total cost of the canal itself. Under the plan for this year the sum of 400 million roubles is appropriated for the construction of the Moscow-Volga Canal. This canal will be one of the greatest construction schemes in the world, which in volume and difficulty of construction will exceed the world's biggest structures of this kind, including the famous Panama Canal.

In addition to great industrial schemes contemplated an ever-growing number of structures are designed for other purposes, thus, a commencement has been made on the Moscow subway, in which 350 million roubles is invested this year. Of the hydro-electric stations in the 1934 plan, the place of Dnieprostroi will be taken by stations in Yaroslavl and Perm, which are the first units of the Volga hydro-electric stations. The Gorki hydro-electric station will be built next.

This year we are beginning to make preparations for the construction of one of the first giant undertakings connected with the North Caucasus, namely, the Volga-Don Canal. In 1934 a modest sum is assigned for this construction. The money will be used for designing, prospecting, and drawing up an estimate. In 1935 the construction of this canal will be developed at full speed. In addition to the Volga hydro-electric station, mention must be made of the opening of construction work on three

new metal giants—the Bakal and Khalilova plants and the second Kuznetsk plant. Provisions are being made for the development of prospecting and designing in connection with the construction of a metal plant in the Far East to use local coal and ore. Operations will also be started by 39 coal mines, with an aggregate capacity of 21.6 million tons a year, and 13 cracking plants with a capacity of 22 million tons of oil a year. The latter will be of tremendous importance in supplying fuel (benzine and kerosene) to the automobiles and tractors in the country.

Other plants to start operations will be :—One blast furnace in the Krivoi Rog metal plant, with a capital investment of 212 million roubles; the Nuvo-Tula and Novo-Lipetsk metal plants, estimated to cost 90 and 100 million roubles, respectively; the Makeyevka and Sinar pipe-rolling mills, the first Urals pipe-rolling mill, the Chelyabinsk zinc plant, the Dniepropetrovsk magnesium factory, and the new Kramatorsk machine-building plant, estimated to cost 248 million roubles. Work will also be started by such plants as the Ural coach-building factory, which will be one of the biggest plants in the world producing large-size railroad coaches; the Bezhitsa steel smelting plant; the Ufa motor plant; the Samara carburetter plant; and the Siberian mine-equipment factory. Partial operations will be commenced at the Amur shipyard, the consumer of metal from the future metallurgical plants in the Far East. The power stations of Babriki, Stalinsk, Samara, Gizeldon, and Krasnozavodsk in Kharkov, will also be put into operation.

It is claimed that the 1934 investments will mark a further increase in the capacity of the Soviet industries, and some indication of the possibilities are shown in the following brief summary of developments. In the iron industry, for instance, 13 new blast furnaces will be opened, including a furnace in the Kuznetsk plant with a capacity closely approximating four million tons a year, as compared to the entire pre-war capacity of our metal industry, which amounted to 4.2 million tons a year. There will also be started 40 new open hearth furnaces, 18 electric furnaces, 28 rolling mills, including three blooming mills, and 25 rolling presses. The capacity of the steel plants will grow by 2.3 million tons, and that of the rolling plants by 1,850,000 tons a year. The four pipe-rolling mills, which are to be opened in 1934, will produce 200,000 tons of pipes a year, which are necessary for an increase in the oil output, and for laying oil pipe-lines. The new coke batteries will raise the capacity of the coke industry by 3.9 million tons a year. The length of the railroads will reach 83,600 km., while the electrified lines will grow from 320 km. to 969 km.

These capital investments will undoubtedly strengthen and extend the technical base of our own heavy industry, upon which the Soviet is developing the entire national economy, and will strengthen its defensive capacity; on the other hand, it will ensure a tremendous growth of capacities among the plants of the light and food industries, and in the industries producing articles of general consumption.

Railroads.

Considerable work for the reconstruction of railroad transport was carried out in 1933. The number of locomotives has been increased by 970, in addition to which there have been built 24 electric locomotives, 20,800 freight coaches, and 1,625 passenger coaches. The technical reconstruction of the railroads will be continued at a vigorous pace, and capital investments in 1934 will amount to 3,707 million roubles. The number of locomotives will be increased by 1,283. There will also be added 20 trunk line Diesel engines, 40 electric locomotives, 38,000 freight coaches, and 2,000 passenger coaches.

Powerful railroad repair shops and factories for the production of materials necessary for the reconstruction of permanent ways are being built. About half a milliard roubles will be invested in the improvement of permanent ways and an enormous amount of work will be carried out. A number of new railroad lines are being built. These include lines of industrial importance, such as the Karaganda-Balkhash line, the Chikment-Akmolinsk-Kartalinskaya line. The Novosibirsk-Leninsk line is about to be completed, and a second track will be laid immediately.

In the Ukraine railroads are also being built, such as the Grishino-Pavlograd line, the Zolotonosha-Mironovk line, and others. In Transcaucasia the Black Sea railroad is being built. This year track-laying will be completed and traffic will be opened to Gagri in the northern direction. The Akhal-Senaki-Ochimchiri and Tkvarchali branches are about to be completed.

Amongst further developments contemplated mention may be made of some transport plans for 1934. Arrangements are being made to increase the water transport traffic. This increase is expected to amount to 28.8 per cent. in river transport and 29.6 per cent. in maritime transport. Shipment by the Soviet mercantile fleet will increase by 52.1 per cent. The preparation for the shipment of oil along the Volga and Dnieper, and the organisation of shipments along the upper Irtysh, Balkhash, Amur, Lena, and other Siberian rivers are the most important tasks of water transport. In civil aviation the length of air lines will amount to 48,000 km. in 1934, chief attention being directed to the establishment of passenger connections in those areas where communications by land are difficult, as in Central Asia and Eastern Siberia. Considerable work has also commenced on improvement in the postal and telegraph service, for which 348 million roubles has been allocated.

It has only been possible to refer to some of the main projects included in the 1934 plan, but these are sufficient to indicate that the industrial experience in this country could be used to assist in this work of reconstruction and developments to a much greater extent than at present. It is, therefore, hoped that commercial negotiations, now taking place, will result in the completion of an Anglo-Soviet trade agreement without undue delay, because we have every reason to believe that, with an amicable arrangement, many British firms would benefit from Russian orders for plant and equipment incorporated in this 1934 plan.

A.S.T.M. Standards and Tentative Standards.
1933 Index.

THE issue of standards and tentative standards for 1933, recently issued by the American Society for Testing Materials, reviewed in our issue of November last, has been supplemented by an Index, which is now available. This is designed primarily to be of service to those interested in ascertaining if the Society has issued any specifications, method of testing, recommending practices or definitions on a specific subject in the field of engineering materials and the allied testing field. To those familiar with the Society's standards, this Index comprises a valuable reference which facilitates the location of any specification or method of test in the volume of specifications recently published.

This Index has been completely revised, and while the method of indexing is essentially the same, the subject matter has been arranged to enable references to be located quicker than with previous publications. The standards are indexed under appropriate key-words, according to the materials or subjects to which they apply. The items under each subject are arranged alphabetically according to the significant word in the title. Under any key-word subject, where three or more items cover related subjects, these have been grouped alphabetically and indented under the significant word or words common to the titles of the several items. The Index has a heavy paper cover and comprises 124 pages. Copies are furnished without charge to those who send requests to the American Society for Testing Materials, 260, S. Broad Street, Philadelphia, U.S.A.

Some Recent Inventions.

The date given at the end of an abridgment is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2, at 1/- each.

Continuous Heat-treatment Strip Furnaces.

IMPROVEMENTS relating to electric furnaces, such as are used for the continuous heat-treatment of strip, wire, etc., include economy of heat, while the work is travelling through the furnace. Gas or a mixture of gas circulates over the material in a cooling chamber situated near the exit, and extracts heat from the heated material; it is afterwards drawn through an insulated passage or flue, situated external to the furnace proper, to a preheating chamber arranged near the entrance end of the furnace. Here the hot gas in turn gives up some of its heat to the cool incoming material, and is returned via a similar insulated passage or flue to the first-mentioned chamber at the exit end.

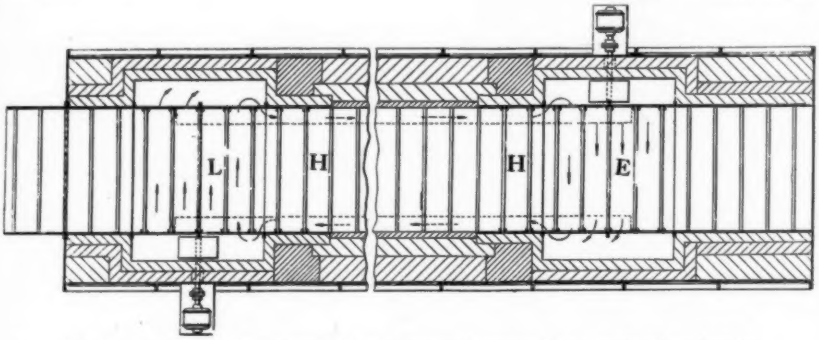


Fig. 1.—One form of continuous electric furnace incorporating a preheating chamber arranged near the end of the furnace.

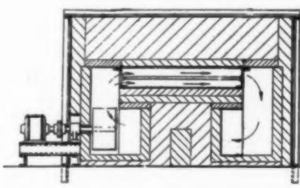


Fig. 2.—A cross section through the cooling chamber of the furnace showing the direction of flow of the combustion gases

Each recuperative chamber is provided with a series of flexible flaps, either of laminated metal or metal reinforced material mounted in the roof and floor, and adapted to rub on the upper and lower surfaces of the metal strip. These flaps serve as heat conductors and also to exclude cold air.

In the accompanying illustrations, Fig. 1 shows a plan of one form of electric furnace incorporating the improvements, and Fig. 2, a cross-section on the line XY through the cooling chamber. The pre-heating section E, the main-heating section H, and the cooling section L, are connected by ducts for the circulation of the gaseous heat-carrying medium. These ducts are arranged beneath the heating section H, and are connected to the preheating and cooling sections of the furnace by uptakes, with fans, and downtakes. Although it is not necessary to provide two fans as shown, it has been found advantageous to do so, in order to avoid local pressure conditions which tend to produce undesirable air currents through the furnace.

394,313. MARTIN VAN MARLE, of Kingswinford; and G. W. B. ELECTRIC FURNACES, LTD., of London. June 19. 1933.

Rolling-mill Housings.

A NOVEL construction of housing and arrangement of rolls is shown in the accompanying illustrations, in which each roll is mounted in an overhung position directly upon the end of a motor-shaft which projects beyond its bearing, and the motor-casing is mounted between the two standards of the roll housing. In this way is obtained accessibility and easy adjustability of the rolls, and at the same time the rotating masses pertaining to a roll are diminished to a minimum. The insertion pieces of the roll housing, constructed as a motor-casing and motor-carrier, also require a special construction of the motor itself, in view of the permissible roll diameter, the wound stator being arranged to right and left of the rotor at the side of the direction of rolling, in order that the rotor may be able to be constructed with as large a diameter as possible, and the dimension of the stator, measured from its axis towards the axis of the adjacent motor, being not greater than the radius of the rotor. Any kind of motor, direct-current or three-phase current, may be employed. The roll shaft, which at the same time constitutes the motor-shaft, is preferably supported in roller bearings. While one roll, the lower one, for instance, need not be adjustable in its axial direction, the other roll must be so arranged as to be axially movable, in order to enable the notches of the pass to be accurately superposed in relation to one another in the roll bodies. This axial adjusting of the rolls is, according to the invention, effected by a positioning disc, which is fitted upon the non-working side of the housing, that is to say, the unendangered side.

The shifting of the roll when wear of the grooves has taken place is effected by means of pressure screws, which can be actuated individually as well as collectively by means of positioning discs, both upon the working or endangered side, and upon the other or unendangered side of the housing. The upper insertion piece of the roll housing, carrying the upper roll and its driving motor, is, of course, balanced and constantly pressed upwards against the pressure screws, so that a jump or crack of the roll does not occur at each entry.

Referring to the illustrations, the rolling mill comprises a pair of overhung rolls *a* mounted on spindles *b* on which motor armatures *c* are directly mounted, the motor stators *g*, Fig. 1, being fitted directly in the roll spindle housing.

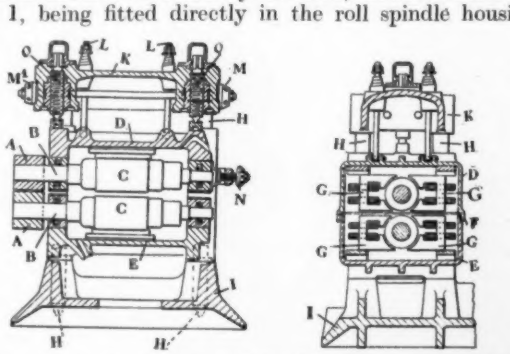


Fig. 1.—Two views of a novel roll-housing arrangement in which each roll is mounted in an overhung position.

The upper roll spindle may be adjusted axially by a screw gear *n*. The spindle housing comprises a lower casing *e* and an upper casing *d* which overlaps the lower casing at *f* to make a dust, etc., excluding joint. The casings are positioned by four pillars *h* which seat in the base *i*. Screws *o* adjust the upper roll against the pressure of springs *l*. The motor stators are so formed as not to exceed in height the diameter of the rotor.

395,208. SCHLOEMANN AKT-GES, Düsseldorf, Germany. July 13, 1933.

Drilling Machine Improvements.

The accompanying illustrations, Figs. 1 and 2, show a vertical section and a plan of a clutch-controlled mechanism constructed for a radial-arm drilling machine of the kind in which the radial arm is moved vertically by an electric motor. When the motor is started the mechanism first releases the clamping means for the arm, and then clutches the motor to the raising and lowering mechanism. The radial arm C has a split boss D vertically adjustable on the rotatable pillar-sleeve B by means of a screw N, and

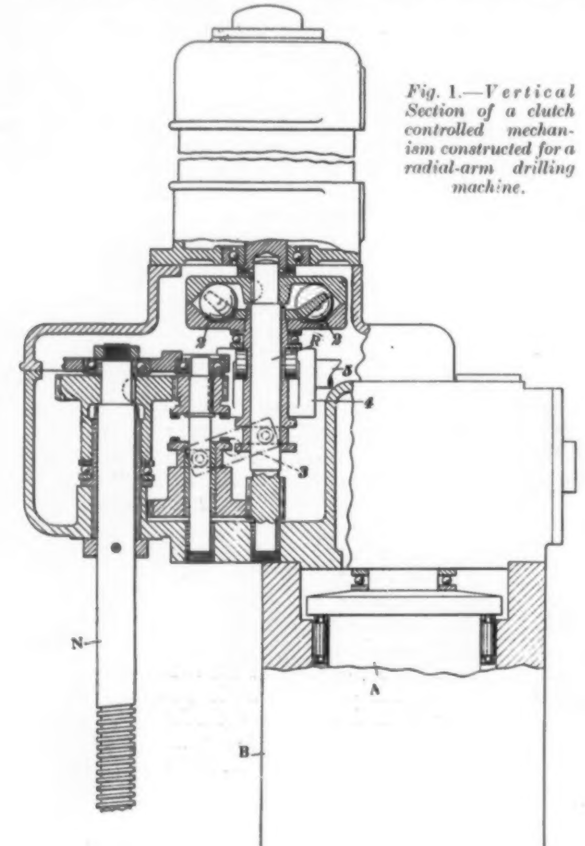


Fig. 1.—Vertical Section of a clutch controlled mechanism constructed for a radial-arm drilling machine.

clamped to the sleeve by bolts G which are actuated by cams H acting on levers K attached to the bolts. The levers have heels L rocking on projections on the boss D. The cams H are mounted on a shaft which is rotated to the closing position by a spring, link, and lever on the shaft. The spindle R of the electric motor carries a pinion engaging a gear capable of being clutched by teeth to a pinion meshing with a gear on the screw. The centrifugal control is produced by balls 2, Fig. 1, acting on the inner bevelled surfaces of discs, the latter being fixed on the motor-spindle R, whilst the former is slidable thereon and carries a sleeve engaging one end of a lever 3 whose other end engages the clutch gear. A second lever 4 is engaged by the sleeve, and is secured to a shaft 5, Fig. 2, connected by bevel gears 6 to the clamping shaft. On starting the motor by a push-button a sleeve is depressed, first rocking the shaft 5 and releasing the clamp against the action of the spring, and subsequently rocking the lever 3 to engage the clutch and rotate the screw N for raising or lowering the arm C. On stoppage of the motor, the spring again clamps the arm and returns the sleeve and clutch to the normal position shown in Fig. 1.

395,463. J. Archdale and Co., Ltd., and J. Jewsbury, Birmingham. July 20, 1933.

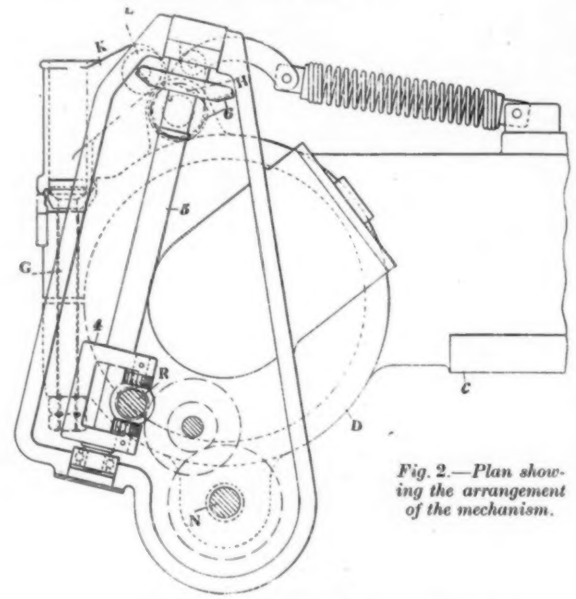
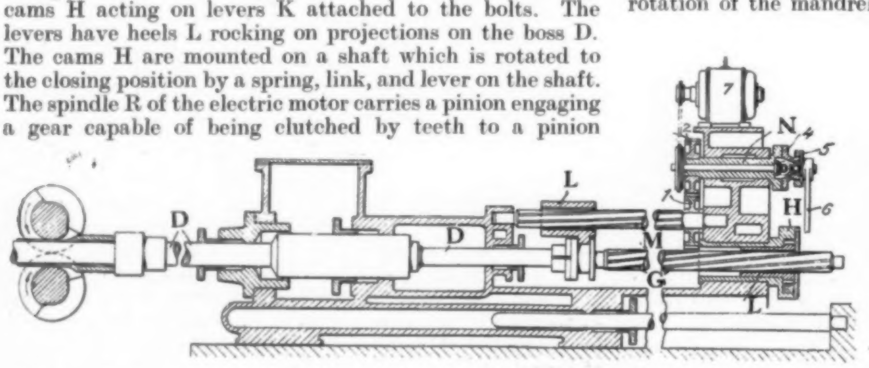


Fig. 2.—Plan showing the arrangement of the mechanism.

Rolling Mandrel Carriages.

An improved feeding device for the mandrel of a pilger rolling mill has been devised in which the helically-grooved spindle secured to the mandrel rod is connected to the nut of the spindle by automatically operating mechanism in order to control the rotation of the nut during the return stroke of the spindle to effect the necessary compensation in the angle of rotation of the spindle. A sectional elevation of a feeding device for the mandrel of a pilger rolling mill incorporating this improvement is shown in Fig. 1, while the automatic mechanism is shown in Fig. 2. Referring to these illustrations, the rotation of the helically-grooved spindle G of the pilger mandrel D in its nut I which ratchets in the casing H is controlled by mechanism coupled to the spindle G, and causing the rotation of the casing relative to the ratchet and spindle to compensate the angle of rotation of the mandrel D in accordance with the length of its stroke. The spindle G oscillates a second nut L on another helically-grooved spindle M, the rotation of which is transmitted through gear wheels 1, 2 and a hollow shaft N to a rod 6 connected to the casing H. The amount and direction of rotation given in the casing H is determined by mounting the connecting-rod 6 on a slide block 5 which can be traversed along a slide 4 fixed on the rocking-shaft N, by hand, or by an electric motor 7 coupled by chain and bevel gearing to a screw which slides the block 5 along, and thereby varies the throw and direction of pull of the connecting-rod 6 on the casing H of the ratchet nut P.



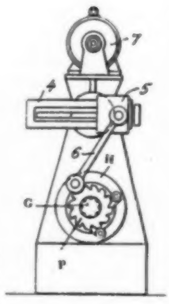


Fig. 1 —Section showing feeding device for the mandrel of a pilger rolling mill. Fig. 2—The Automatic mechanism.

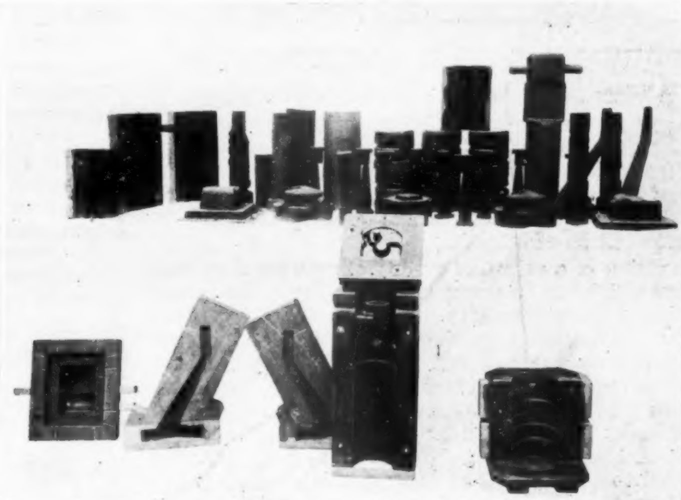
395,465. Mannesmannröhren-Werke, of Düsseldorf, Germany. July 20, 1933.

Recent Developments in Tools and Equipment

THE AUGUST-BORRMAN CORE-BLOWING MACHINE

DURING comparatively recent years there has been a more general desire to make greater use of machines in foundries. It has long been appreciated that the production of moulds is essentially an art, but it is now recognised that in order to effect economy in production, particularly in repetition work, machines are essential. Various types of moulding machines have, of course, been used for many years, and to a lesser extent core-making machines too have assisted rapid production, though there are many foundries where no mechanical aids of this character have yet been introduced. Rapid progress, however, is being made in the development of suitable machines, and the time is not far distant when the foundry without moulding and core-making machines will be an exception. One firm which is doing much to facilitate the work in the foundry is August, Ltd., of Halifax, whose most recent development is a core-blowing machine which is of outstanding interest.

The largest of the three sizes of this type of core-blowing machine, equipped with a bucket sand loader.



Group of oil sand cores and wooden core boxes, typical of an ordinry run of cores blown on the largest of this type of machine. The tallest core is 2 ft. high and weighs about 40 lbs.

Considerable research and experimental work has been carried out with a view to the production of cores by mechanical means. Simple hand-squeeze and turn-over machines, adopting many of the principles of moulding machines, have been developed for this purpose, which have proved useful and efficient; but many investigators felt that such machines did not exploit all the possibilities, and in both America and Europe machines were evolved for producing cores by which the core sand was actually blown into the core-box. Simple as this operation seems, the early efforts presented many difficulties, and the machines then produced were limited in their application to the blowing of the simplest of cores and in very light oil sand.

The difficulties experienced in the adoption of the principle of core blowing and its extension to the production of intricate cores and to the use of a variety of types of core sand were due, in some cases, to the design of the machines, but more particularly to the aeration of the sand during the time of blowing. In an effort to overcome these difficulties, the August-Borrmann core-blowing machine has been evolved, by which any type of core, of a size within the capacity of the machine, can be produced, and any type of core sand satisfactorily used. The core-boxes may be of wood or metal, and the machine requires very little skill to operate.

To cover a general range of cores, this machine is made in three standard sizes having a sand container of 20, 50, and 100 lb. capacity respectively. The largest of these is shown in the accompanying illustration. It is supplied with air at 80/100 lb. pressure per sq. in., and both the agitator and the bucket loader are direct motor driven. The bucket, at floor level, is charged with the required core sand, and an easily accessible lever controls the hoisting of the bucket to deliver the sand to the hopper, which is integral with the machine. The core-blower releases sufficient sand from the hopper to fill the container, and while the container contains sand, only two levers are operated in the whole core-blowing operation.

The empty core-box is placed upon the table of the machine, so that its blowing hole registers with the hole in a blowing slide fixed to the base of the container. The operation of one lever causes the table to rise, which clamps the core-box vertically between the table and the blowing slide, and also causes two horizontal clamps to operate so that the box is held firmly in all directions. When the core-box has been fixed in this way a second lever is operated which actuates the blowing slide, permitting the sand to be blown into the core-box. Reversing the operation of these two levers completes the work done by the machine, and releases the core-box, which is removed for stripping. The time occupied in completing the cycle of operations is almost negligible, and varies very little either on different sizes of machines, with different sizes or types cf cores, or with different sands. No difficulty is experienced in blowing cores with this machine, in which rods or vents are necessary, and existing core-boxes are usable.

The art of core-blowing consists, very largely, of an understanding of the technique involved in releasing properly the air which would otherwise be trapped in the

core-box. For the majority of core-boxes a standard air-release plate, supplied with the machine, is usually sufficient, whilst for other boxes the provision of extra air releases at certain points is a comparatively easy matter.

Core-blowing machines of this type are in regular daily production on all types of cores, from a few ounces to 40 lb. in weight, and with all types of artificially or naturally bonded sands for the lightest or heaviest of work. Efficient cores can be produced at a very rapid rate, whether they are to be produced in large quantities or when only a few are required. For example, we understand that in one British foundry two medium size machines are now averaging 10,000 greens and cores per week, and in another foundry one smallest size is producing regularly an intricate core in oil sand at the rate of 150 per hour, whilst in a jobbing foundry, formerly employing six or seven core-makers, one unskilled man is now producing on one largest type machine all the cores the foundry requires. Gradually, the slow, laborious and costly method of hand-core making will, wherever possible, give place to the machine, which is simple, quick, and cheap, and this machine is a very important contribution in this direction.

PARKERIZING AND BONDERIZING.

Some Notes on these Rust-proofing Processes.

Many processes are in successful operation that have for their object the protection of iron and steel surfaces against rust. Not the least important of these are the rust-proofing processes known as Parkerizing and Bonderizing, each of which has its special advantages and upon which a few notes will be of interest.

Parkerizing is a scientific system of rust-proofing iron and steel which can be commercially employed by manufacturers, and lends itself to a variety of pleasing black finishes. The process is simple, effective, and cheap, requires no electric current, and can be handled by unskilled labour. The parts for Parkerizing should be free from scale and grease, and are then immersed in a solution for about 60 mins., which is made up from Parco rust-proofing powder and boiling water. The surface of the metal is converted to an insoluble phosphate which is impervious to rust under ordinary atmospheric conditions. To complete the rust-proofing, however, it is necessary to apply one of the range of Parker finishes or treat with paint, enamel, or lacquer. This process is suitable for practically all kinds of iron and steel parts as it does not in any way affect the physical properties of the metal such as contour, magnetism, or temper. There is no appreciable growth, so that parts which are made to fine limits lend themselves to it.

Bonderizing was developed as a base for paint, enamel, or lacquer, to deal with parts having large surface areas on a production basis. It is a chemical priming operation which converts the surface of the steel to a practically non-metallic coating which is quite opaque and which seals the pores of the metal. In addition, the surface is chemically clean and ready for enamelling, etc. Any surface rust which may be present is converted during processing. Like Parkerizing, parts should be free from scale and grease, and are then immersed in a solution of Bonderite rust-proofing powder and boiling water for 5 to 10 mins. The Bonderized surface obtained is sufficiently absorbent to ensure permanent cohesion to any applied lacquer or enamel, and as the surface is opaque it facilitates colour matching. The strength of the solutions is maintained by the further addition of powder according to the amount of work processed, and this strength is checked by a simple titration test.

These processes are operated under a simple form of licence agreement involving a fee of £2 annually, which covers both processes; the owners of the patents being the Pyrene Company Ltd., Great West Road, Brentford, Middlesex.

PICKLING EQUIPMENT.

Pickling is a process in which so many controlling factors are involved that proper results can only be obtained when the conditions have been standardised for the particular base metal to be treated. It is now recognised as one of the most important aids to manufacture, and the discouraging conditions which formerly existed in many plants, and which were responsible for irregular results, have been gradually, though not entirely, eliminated. Modern thought and progress, particularly in effecting improvements in equipment and in the control of the operations, have led to considerable increase in efficiency. Perhaps there is no better example of this in Europe than the pickling department of the Ford Works, at Dagenham.

As the latest of the productive centres of this company, Dagenham represents the results of over 30 years' experience of manufacturing on a vast scale, and thus every detail of the factory's construction and equipment may be regarded as having passed exhaustive tests of the most practical kind before being incorporated in the design. Fundamentally, of course, the pickling process, as employed at these works, does not differ from that carried out in the majority of kindred factories. All important parts, of which rear axle and steering components, crankshafts, etc., are examples, are pickled after leaving the forging machines, to remove scale and reveal material or forging defects, such as cracks, overlaps, etc. In these works, however, the quantity of parts handled is exceptional. During a recent month no fewer than 572,386 forgings of various kinds were pickled, and arrangements are in hand to deal with an output three times this size.

As in practically every other department of these works, the conveyer system is employed. The conveyer is of the overhead reel type, with closely-spaced hangers to which are attached Monel metal baskets containing the parts to be pickled. By means of this endless conveyer the parts are passed in succession through the pickling medium, through a cold water spray, and then through a hot water tank. The conveyer is fed at a point adjacent to the forging machines. As the parts reach a point above the pickle tank they are automatically lowered into the acid. After passing through the tank they are raised, again automatically, and meet the cold water spray, and are then lowered into the hot water tank. The parts are dried during the return journey to their starting point. In the case of large forgings, or others needing longer immersion in the acid, the process is repeated. In normal cases, the process from the time the parts enter the pickle tank until they emerge from the hot water tank occupies about 22½ mins. After being removed from the conveyer the parts are inspected and then fed to the machine shops.

Pickling has been the subject of considerable attention by the laboratory staff at these works, the aim being to obtain a pickling medium which will remove scale in the shortest possible time without unduly attacking the surface of the metal. This object has been attained by making chemical additions. The process is also constantly supervised by the laboratory to ensure the pickling being carried out with the minimum consumption of acid. It will be obvious that the conveyer system employed at Dagenham has substantial advantages in speeding up output and in making for a smooth flow of production. It has a further advantage, which is important, although it did not actually determine the adoption of the conveyer system, namely, the fact that the parts are constantly in motion contributes toward the rapid and even action of the acid.

The baskets and brackets are of orthodox design, and Monel metal is used in all cases because of its resistance to the corrosive effect of the acid. The tanks containing the pickling medium are lined with chemically pure lead, which effectively resists the attack of the acid. To prevent the spreading of injurious fumes the tanks are surmounted by cowls, through which the fumes are removed to the outside air by means of forced draught.

Business Notes and News

Electric Welders in Shipyards.

The controversy between the Shipbuilding and Employers' Federation and the shipyard trade unions regarding electric welding is still unsettled. At a conference held in Edinburgh between their respective representatives, the proposal for the creation of a new skilled class of operatives in electric welding, put forward by the Federation failed to reach agreements, and a deadlock has arisen. It was suggested by the Federation that the new class of operatives was necessary, in view of the far-reaching changes taking place in the industry. The unions, on the other hand, consider there is no need for a new class, and contend that if there were a need for more welders, it could be met by the extension of the training of apprentices in existing trades.

This conference was presided over by Mr. T. Graham Robertson, as independent chairman and, at the close of the meeting, it was stated that since the representatives met last November, separate and informal discussions had taken place between the independent chairman and the interested parties. At to-day's general conference, a statement involving certain modifications of the proposals was made by Mr. G. T. Edwards, President of the Employers' Federation, and a statement for the trade unions was made by Mr. W. Sherwood. No agreement was reached, and the President of the Employers' Federation then intimated that the matter was not one which his federation was prepared to refer to arbitration. In the circumstances, the independent chairman, in terms of the procedure agreement between the parties, adjourned the general conference until January 19. It is not at present anticipated, however, that the parties will meet again to discuss the matter. If no further meeting takes place, the general conference will be closed on January 19.

Cologne Exhibition of Chemical Plant and Apparatus.

The site of the above Exhibition, which will be held in Cologne from May 18 to 27, 1934, is that formerly occupied by the "Pressa" exhibition, situate on the right bank of the Rhine, and in close proximity to Cologne cathedral—*i.e.*, in the centre of the town. The Achema exhibition, in the beautiful Rhine Park, will, in itself, represent a congress town, and be attractively and completely planned in a way hitherto impossible for an exhibition of this type. Not only the exhibition halls, but also the lecture halls, meeting rooms, restaurants and refreshment room, will be so situated that they form a combined whole, only a short distance one from the other, thus obviating loss of time and energy on the part of the visitors to the congress and the exhibition.

The three halls provided for the Achema occupy in all a space of about 190,000 sq. ft., most of which has already been taken by leading firms in the chemical equipment industry, for their exhibits. The "Staatenhaus" situated only a few steps distant from the exhibition halls will be arranged as lecture rooms, as in addition to the Achema exhibition, the Congress of the German Chemical Trades' Association consisting of 17 special groups, and those of three allied associations will also be held simultaneously. Provision has, therefore, been made for lecture rooms for all these organisations, so as to enable them to engage in their scientific and technical discussions. Not only the German Chemical Trades Association, but also the "Dechema" Deutsche Normenausschub E.V., Kolner Bezirksverein Deutscher Ingenieure E.V., Verband Deutscher Apparatebau-Anstalten E.V., Verband für autogene Metallbearbeitung, Verein Deutscher Eisengiebereien. Verein Deutscher Kupferschmiedereien, Vereinigung der Deutschen Dampfkessel-und Apparate-Industrie E.V., and other prominent and important scientific and technical associations will hold conferences during the exhibition.

At a meeting of the creditors of the Darlington Rustless Iron and Steel Company, Ltd., held on December 15, a scheme of arrangement was carried by a large majority. The Midland Bank has agreed to advance to the company up to £10,000, taking as security a prior lien debenture. A further £10,000 will be secured by issuing a first debenture which will be subject to the bank's charges and will carry interest at the rate of 6 per cent. per annum. Creditors will be paid by a second debenture.

Grampian Hydro-Electric Scheme.

The additional power station erected at Tummel Bridge completes the second stage of the Grampian Electricity Company's hydro-electric scheme for making use of the waters of Perthshire lochs. The first part of the project was the erection of a power house, supplied from Loch Ericht with water which discharges into Loch Rannoch to be used a second time. The power house at Tummel Bridge takes water from Loch Rannoch to an intake dam on the River Tummel, at Dunalastair, is conveyed from there by a three-mile concrete-lined aqueduct, cut in the slope of Schiehallion, and led in two steel pipes, 12 ft. 6 in. in diameter, down hill to the power house, which contains two generating units, each composed of a Francis turbine developing 24,000 b.h.p., with a generating voltage of 11,000. The current passes into a line from Rannoch power house for transmission to the distributing station of the Central Electricity Board at Abernethy. The works have been designed and constructed by Messrs. Balfour, Beatty and Co., London.

Multiple Etching Machine.

At the recent exhibition of scientific instruments and apparatus, arranged by the Physical Society, and held at the Imperial College of Service and Technology, South Kensington, a new multiple etching machine was shown which marks 15 stainless knives or other articles at a time by means of an electrical process. The work is stated to be done four times as rapidly as by the old acid etching process, and at a fifth of the cost.

In the trade section 81 firms exhibted their latest products. One device exhibited, which is finding fresh fields of usefulness is the cathode ray tube. This contrivance generates a stream of electrons which is rendered visible where it impinges on a fluorescent screen ; by electrical or magnetic means the stream can be deflected. It is employed in television, and in the cathode ray oscillograph, which can be used to demonstrate alternating-current phenomena ; and there are other applications in industrial engineering, where a continuously-operating visual indicator is required.

New Officers for A.S.T.M.

Headquarters of the American Society for Testing Materials have been moved from the Engineers' Club Building, 1315, Spruce Street, Philadelphia, to more adequate offices in the Atlantic Building, 260, S. Broad Street, in the same city.

The new rooms comprise about 2,600 sq. ft. on the fifth floor of the building to be devoted to offices, reception room, members' lounge and boardroom ; and 850 sq. ft. on the fourth floor for storage of publications and use as a shipping and general workroom. The increase in total floor area is some 40 per cent., while the general office space is nearly 60% greater.

A large and more attractive boardroom has been planned, and most important, an adequate reception room and members' lounge will be provided. Greatly improved facilities for meetings of administrative committees will be available. The new rooms are excellently suited to the present needs of the society, and for some little time in the future.

The Tin Quota and Congo Producers.

The tin-control agreement which came into operation on January 1, will continue in operation for three years from that date, and may be extended, providing such extension is considered twelve months before the date on which the agreement would normally expire. The signatories to the agreement include Bolivia, Malay States, Netherland, East Indies, Nigeria and Siam. The Belgian Congo and Ruanda-Urundi producers consider the possibility of coming into line with the International Tin Committee, at a recent meeting at which it was stated that, owing to the rapid increase of tin production in the Congo, producers could not enter into engagements for a longer period than two years. In addition, the quota of 10,000 to 12,000 tons for the years 1934 and 1935 which the Committee desired to fix, was considered insufficient, Congo producers demanding 17,000 tons. It is expected that the Congo producers will present a definite programme at the next meeting of the Committee, to be held on February 22, on the acceptance of which they will be ready to join in the control arrangements.

Works Removal.

The London and North Eastern, and Southern Railways accomplished a noteworthy performance in the largest factory removal ever undertaken by these companies. Some time ago the combined firms of Aveling and Porter, and Barford and Perkins, of Rochester, specialists in road rollers and other heavy machinery, decided to transfer the whole of their plant and manufacturing activities, and 150 of their keymen, besides their scale and technical staff, to a new factory adjoining the railway at Grantham, 120 miles away. The scheme entailed the dismantling and transport by rail of nearly 10,000 tons of machinery, and its re-erection at Grantham. Some 30 wagons a day have been loaded and dispatched.

Shipbuilding Industry and Skilled Workers.

One of the grave results of the depression in the shipbuilding industry is the loss that is being experienced in skilled operatives. Despite the better outlook in this industry, there are still about 80% of the available berths unoccupied by vessels, and unemployment amongst the workers is still about 57%, which is much higher than any other large industry, and compares with a general average of unemployment of about 18%. The seriousness of this situation is stressed by Mr. O. S. Swan, of the Shipbuilding Employers' Federation, who states that the industry is gradually losing its skilled personnel in the yards. The older craftsmen are leaving behind them a generation less experienced through sheer lack of employment, and for that reason unskilled and without the capacity to turn out work like its predecessors.

Brymbe Steelworks.

The Brymbo Steelworks, which were closed down in the middle of 1931, were acquired a few months ago by a new company, with Sir Henry Robertson as chairman of directors, and re-opening of the works at an early date is contemplated. About fifty men have already been started for repair work and for reconditioning the plant, and it is hoped to be in full swing towards the end of April. In connection with the re-opening the following appointments are announced:—Mr. Glyn M. Jones, manager; Mr. Thomas Roberts, process manager and metallurgist; Mr. T. G. Littleboy, chief engineer; and Mr. J. L. Daniel, chief assistant engineer. The secretary of the new company is Mr. W. L. Venables.

Mineral Basis of Life,

In a recent issue of the *British Medical Journal* Dr. J. H. Sheldon gives a very interesting summary of what has been discovered during the last few years concerning the presence of such metallic elements as silver, tin, manganese, copper, etc., in various parts of the human body. This has only been possible as a result of modern methods of research, especially new ways of proving the presence of certain substances by means of the absorption of light passed through a spectroscope, which have shown that the mineral elements of the body are not limited to the half dozen or so described by older authorities.

It is now known, for instance, that copper, which occurs mainly in the liver, is closely connected with the manufacture of haemoglobin by the body. This substance is the red colouring matter of blood responsible for the carriage of oxygen to the tissues, and in certain forms of anaemia the use of copper is beneficial in restoring the blood to a normal condition. A curious discovery recently made is that rubidium is not only present in traces in adult human tissues, but a greater amount than the average is found in infants dying of a curious affection of the stomach. Silver is found especially in the thyroid gland and also in the tonsil.

Tin is found in certain organs, but especially in the tongue, where it is concentrated in the covering membrane to a level of many times the average found elsewhere. Manganese is found especially in the suprarenal glands in some cases, while the liver and pancreas yield regularly definite amounts of this mineral. Another metal which plays some curious part in the chemistry of the body is magnesium, for it has been found that if sufficient is not taken in with the food a serious type of damage to the kidneys occurs.

The amounts of these elements are, of course, very small, but it is apparent that they have considerable influence on life; it is obvious therefore that these new researches have a very great importance for the future, and there is an immense amount of work waiting to be done to explain some of the curious findings here summarised.

Some Recent Contracts.

John Brown and Co., Clydebank, have received an order for a twin-screw motor liner for the Commonwealth and Dominion Line. The vessel will be 452 feet long, and have a gross tonnage of approximately 12,500 tons. She will be fitted with a new type of Doxford fabricated Diesel engines, constructed by Messrs. John Brown and Co., and is expected to develop a speed of about 16 knots on service. The vessel is designed for carrying meat from Australia and New Zealand, and will be fitted with special refrigerating equipment for this trade. A commencement has already been made with this vessel, and work is to be speeded up in an effort to deliver the vessel this year.

The Admiralty state that it has been decided to begin the construction of a further sloop in the 1933 programme. The vessel will be built at Chatham, and will be named *H.M.S. Deptford*. This is the third sloop of the 1933 programme to be ordered. Of the other two, the *Kingfisher*, a coastal vessel, is being built by the Fairfield Shipbuilding and Engineering Company, Ltd., and the *Bittern*, a coastal sloop, by John Brown and Co.

The Eagle Oil Company, of London, has placed orders for six oil tankers which are to be built within 15 months of the signing of the contract. Each vessel will be of 11,000 tons deadweight, and the following firms will build one each:—Lithgows, Ltd., Port Glasgow; Blythswood Shipbuilding Company, Greenock; Harland and Wolff, Glasgow; Hawthorn, Leslie and Co., Ltd., Hepburn-on-Tyne; Shaw, Hunter and Wigham Richardson, Wallsend; Furness Shipbuilding Company, Ltd., Harverton-Mill-on-Tees.

The engines will be built by the same firms, with the exception that the Tyneside orders will be supplied by Hawthorn, Leslie and Co., Ltd.

Messrs. Charles Booth and Son, Bradford, have been awarded a contract by the London Midland and Scottish Railway, for building the new station at Upminister Bridge. The value of this contract is about £17,000.

Messrs. Fairbairn Lawson Combe Barbour, Ltd., of Leeds, have received an order from abroad. They will share in a £25,000 order for machinery for a new sack-making mill in Santiago, which is being divided between the Leeds firm and its associate company, the Blackness Foundry, Dundee.

The Pearson and Knowles Engineering Company, Ltd., Warrington, and Messrs. Edward Wood and Co., Manchester, have obtained a joint contract for the reconstruction of the Bessemer plant at Corby, the contract including the supply of steel-melting plant and structures for housing the plant. About 3,500 tons of structural work will be required.

British Insulated Cables, Ltd., of Prescot, have received an order from the Madras Government for aluminium steel reinforced strand, to be used for power lines between Erode and Trichinopoly, in connection with Tykara hydro-electric development scheme. This contract is valued at about £60,000.

Messrs. Mirrleess, Bickerton and Day have received an order for a six-cylinder directly reversible four-stroke engine of 120 b.h.p. for a War Office barge.

Messrs. Hawthorne, Leslie and Co., Ltd., in addition to supplying the engines for the two oil tankers to be built on the Tyne, have received a contract for their Forth Bank engine works at Newcastle. They are to build four steam saddle-tank locomotives and one small electric locomotive for Stewarts and Lloyds.

The Colville Constructional Company, a subsidiary of Messrs. Colvilles, has secured a contract for the structural steel work for the remaining section of the rebuilding of the Bank of England. The order involves about 7,000 tons of steel.

Messrs. G. and J. Weir, Glasgow, have been awarded the contract for boiler-feed pumps for the new electricity station of the Swansea Corporation. The value of this contract is £10,733.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£100 0 0

ANTIMONY.

English £37 10 0 to	£40 0 0
Chinese	26 5 0
Crude	20 0 0

BRASS.

Solid Drawn Tubes	lb.	9d.
Brazed Tubes	,,	11d.
Rods Drawn	,,	8¾d.
Wire	,,	7¾d.
*Extruded Brass Bars	,,	4½d.

COPPER.

Standard Cash		£32 0 0
Electrolytic		35 0 0
Best Selected		34 10 0
Tough		34 0 0
Sheets		62 0 0
Wire Bars		34 15 0
Ingot Bars		34 15 0
Solid Drawn Tubes	lb.	10d.
Brazed Tubes	,,	10d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0 2 9
‡Ferro Tungsten	,,	0 2 6
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.		
NOMINAL 2-4% Carbon, scale 11/- per unit	ton	33 2 6
NOMINAL 4-6% Carbon, scale 7/- per unit	,,	23 0 0
NOMINAL 6-8% Carbon, scale 7/- per unit	,,	22 10 0
NOMINAL 8-10% Carbon, scale 7/- per unit	,,	22 10 0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	,,	34 5 0
Guar. max. 1% Carbon, scale 12/6 per unit	,,	36 10 0
§Guar. max. 0·7% Carbon, scale 15/- per unit	,,	39 2 6
‡Manganese Metal 97-98% Mn.	lb.	0 1 4
‡Metallic Chromium	,,	0 2 8
§ Ferro-Vanadium 25-50%	,,	0 12 8
§ Spiegel, 18-20%	ton	7 10 0
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	5 2 6
20/30% basis 25%, scale 3/6 per unit	,,	7 17 6
45/50% basis 45%, scale 5/- per unit	,,	11 17 6
70/80% basis 75%, scale 7/- per unit	,,	18 10 0
90/95% basis 90%, scale 10/- per unit	,,	30 0 0
Silico Manganese 65/75% Mn., basis 65% Mn.	,,	13 15 0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0 0 4½
Ferro Phosphorus, 20-25%	ton	15 18 0
§ Ferro-Molybdenum, Molyte	lb.	0 5 6
§ Calcium Molybdate	,,	0 5 4

FUELS.

Foundry Coke—	
S. Wales	£1 5 0 to 1 7 6
Scotland	— 1 8 0
Durham	1 1 0 to 1 5 0
Furnace Coke—	
Scotland	— 1 5 6
S. Wales	0 17 6 to 0 18 6
Durham	0 16 6 —

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£52 0 0
*Commercial Ingots	40 0 0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards .. lb.	0 0 9
*Cored Bars ,,	0 0 11

LEAD.

Soft Foreign	£11 9 0
English	13 0 0

MANUFACTURED IRON.

Scotland—	
Crown Bars, Best	£10 5 0
N.E. Coast—	
Rivets	10 15 0
Best Bars	10 5 0
Common Bars	9 5 0
Lancashire—	
Crown Bars	9 0 0
Hoops £10 10 0 to	12 0 0
Midlands—	
Crown Bars £8 0 0 to	9 0 0
Marked Bars	12 0 0
Unmarked Bars	—
Nut and Bolt Bars £6 15 0 to	7 10 0
Gas Strip	10 12 6
S. Yorks—	
Best Bars	10 15 0
Hoops £10 10 0 to	12 0 0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	,,	11d.
†Strip	,,	10½d.
†Sheet to 10 W.G.	,,	11d.
†Wire	,,	11¾d.
†Rods	,,	11d.
†Tubes	,,	1/4
†Castings	,,	1/1½

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—	
Hematite M/Nos.	£3 6 0
Foundry No. 1	3 7 6
,, No. 3	3 5 0
N.E. Coast—	
Hematite No. 1	3 2 6
Foundry No. 1	3 5 0
,, No. 3	3 2 6
,, No. 4	3 1 6
Silicon Iron	3 5 0
Forge	3 1 6
Midlands—	
N. Staffs Forge No. 4	3 1 0
,, Foundry No. 3	3 6 0
Northants—	
Foundry No. 1	3 5 6
Forge No. 4	2 17 6
Foundry No. 3	3 2 6
Derbyshire Forge	3 1 0
,, Foundry No. 1	3 9 0
,, Foundry No. 3	3 6 0
West Coast Hematite	4 0 6
East ,, ,,	3 16 6

SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 18-16 to £1 approximately.

Pig Iron Kr. 93	
Billets Kr. 230-290	£12 13 4-£16 0 0
Wire Rods Kr. 265-320	£14 12 6-£17 12 6
Rolled Bars (dead soft) Kr. 185-210	£10 4 0-£11 11 0
Rolled Charcoal Iron Bars Kr. 290	16 0 0

All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£26 0 0
,, Braziery	24 0 0
,, Wire	—
Brass	19 10 0
Gun Metal	24 0 0
Zinc	9 10 0
Aluminium Cuttings	70 0 0
Lead	10 0 0
Heavy Steel—	
S. Wales	2 10 0
Scotland	2 10 0
Cleveland	2 10 6
Cast Iron—	
Midlands	2 2 6
S. Wales	2 5 0
Cleveland	2 12 0
Steel Turnings—	
Cleveland	1 15 6
Midlands	1 12 6
Cast Iron Borings—	
Cleveland	1 5 0
Scotland	1 18 0

SPELTER.

G.O.B. Official	—
Hard	£12 7 6
English	15 7 0
India	14 0 0
Re-melted	14 7 6

STEEL.

Ship, Bridge, and Tank Plates	
Scotland	£8 15 0
North-East Coast	8 15 0
Midlands	8 17 6
Boiler Plates (Land), Scotland	9 0 0
,, ,, (Marine) ,,	—
,, ,, (Land), N.E. Coast	10 0 0
,, ,, (Marine) ,,	10 10 0
Angles, Scotland	8 7 6
,, North-East Coast	8 7 6
,, Midlands	8 7 6
Joists	8 15 0
Heavy Rails	8 10 0
Fishplates	12 0 0
Light Rails £8 10 0 to	8 15 0
Sheffield—	
Siemens Acid Billets	9 2 6
Hard Basic £8 2 6 and	8 12 6
Medium Basic £6 12 6 and	7 2 6
Soft Basic	6 0 0
Hoops £9 10 0 to	9 15 0
Manchester	
Hoops £9 0 0 to	10 0 0
Scotland, Sheets 24 B.G.	10 5 0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	,,	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	,,	3d.
Under ¼ in. to $\frac{1}{8}$ in.	,,	1/-
Round and Squares 3 in.	,,	4d.
Flats under 1 in. × ¼ in.	,,	3d.
,, ,, ½ in. × ¼ in.	,,	1/-

TIN.

Standard Cash	£227 0 0
English	227 10 0
Australian	—
Eastern	231 2 0
Tin Plates I.C. 20 × 14 box	0 16 6

ZINC.

English Sheets	£25 0 0
Rods	28 15 0
Battery Plates	—
Boiler Plates	—

* McKechnie Brothers, Ltd., quoted Jan. 12. † C. Clifford & Son, Ltd., quoted Jan. 12. ‡ Murex Limited, quoted Jan. 12.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices quoted Jan. 12, ex warehouse.